U.S. AIR FORCE

Project RAND

RESEARCH MEMORANDUM

FC

This is a working paper. It may be expanded, modified, or withdrawn at any time. The views, conclusions, and recommendations expressed herein do not necessarily reflect the official views or policies of the United States Air Force.

The RAND Corporation
SANTA MONICA • CALIFORNIA

RAND RESEARCH MEMORANDUM

[illegible]

[illegible] Jones, M. R. Shapiro
[illegible] Z. Shapiro

RM-2417 July 16, 1959

in brief

Organizations planning the operations of large numbers of high-performance aircraft are faced with a bewildering picture of varying numbers of aircraft, routes, aircraft types, and tasks. A "detailed calculation" approach to development of a plan of operation is too time consuming and limits the number of alternatives which can be developed, while a "conservative approximation" approach does not achieve efficient fleet use.

This research memorandum considers the Flight Operations Planner (FLIOP), a digital computer program designed to reduce significantly the amount of time and effort in calculating detailed flight plans for individual aircraft. By using FLIOP, a planning organization can investigate a wide variety of possible operations without devoting an excessive amount of human time and effort to details. Its use permits the human planner to concentrate more on the general objectives considered, still retaining the assurance that the final result is feasible. FLIOP can also be used with any computer program to solve certain of the more comprehensive mission problems.

The study is in two parts. Part I, which describes generally the problems involved in planning the operations of large numbers of high-performance aircraft and the role of FLIOP, is for the general reader. Part II, which gives a technical description of the technique, is for those who plan to use the routine. Although the B-47 and KC-97 aircraft are used for illustrative purposes, the techniques described are equally applicable to the various models of the B-52, B-58, B-66, KC-135, KB-50, F-101, C-124, C-130, and C-133, and can be applied to any fixed wing type aircraft.

U. S. AIR FORCE
PROJECT RAND

RESEARCH MEMORANDUM

THE FLIGHT OPERATIONS PLANNER

Lt. Col. W. M. Jones
Marvin B. Shapiro
Norman Z. Shapiro

RM-2415

16 July 1959

Assigned to ____________

This is a working paper. It may be expanded, modified, or withdrawn at any time. The views, conclusions, and recommendations expressed herein do not necessarily reflect the official views or policies of the United States Air Force.

The RAND Corporation
1700 MAIN ST. • SANTA MONICA • CALIFORNIA

SUMMARY

This paper is in two parts. Part One is a general description of the problem involved in planning the operation of large numbers of long-range aircraft and a brief description of the particular part of the problem which is addressed by the Flight Operations Planner (FLIOP). This Part is designed to be of interest to the general reader. Part Two is, in its main body, a somewhat more technical description of the technique. It is believed that Part Two will be of interest to those people who might consider using or preparing to use the routine here described. The appendices should be of interest to FLIOP users.

Although the B-47 and KC-97 aircrafts are used in the subsequent parts of this paper for illustrative purposes, the techniques described have proved to be equally applicable to the various models of the B-52, B-58, B-66, KC-135, KB-50, F-101, C-124, C-130, C-133 and can be applied to any fixed wing type aircraft.

CONTENTS

PART ONE

PART TWO

APPENDICES

PART ONE

I. A GENERAL DESCRIPTION OF THE PROBLEM OF PLANNING AIRCRAFT OPERATIONS

Organizations planning the operations of large numbers of high performance aircraft find themselves presented with two basic but associated difficulties. First, the available numbers of aircraft, routes, aircraft types, and tasks can all be so variable as to present a rather bewildering picture. Developing a detailed plan of operations for a large fleet of various aircraft types consumes much more time than used in either the physical preparation of the aircraft and crews or the actual execution of the planned operation. This requirement for a lengthy planning period can become a very real limitation on the operations of such organisations. Second, the plan of operation must either be developed in detail so that its feasibility and adequacy is assured or else be developed by using such conservative aircraft performance parameters that the operation is unquestionably feasible. Neither alternative is particularly attractive; the "detailed calculation" approach because it is too time consuming and limits the number of alternatives which can be developed; the "conservative approximation" approach because it does not achieve a high degree of efficient fleet utilization.

II. THE DESIGNED ROLE OF THE FLIGHT OPERATIONS PLANNER

The Flight Operations Planner (FLIOP) is a digital computer program designed to significantly reduce the amount of time and effort involved in the calculation of detailed flight plans for individual aircraft. By using FLIOP, a planning organization can investigate a wide variety of

possible operations without devoting an inordinate amount of human time and effort to details. Its use can permit the human planner to concentrate more of his attention on the general objectives under consideration, still retaining the assurance that the final result is feasible in all the detailed considered.

III. FACTORS TO CONSIDER IN THE USE OF FLIOP

The Flight Operations Planner is designed to assist the human planner by rapidly calculating the detailed plans of operations of individual aircraft. It is not designed to "optimize" anything (except in the sense that it significantly reduces time used in calculation) unless the human planner asks for certain optimizations.

To use FLIOP, an organization must have convenient access to a computing facility and must have personnel who are (or may become) knowledgable in both the planning of aircraft operations and digital computer applications. Many of the parameters used in FLIOP must be developed by the using organization as they are dependent on and reflect organizational planning factors and policies. As with any complex computer program, a technical description is presentable only in the form of flow diagrams and an assembly listing of the machine code. These (for the IBM 704) together with consultation are available to appropriate organizations upon request.

As with any electronic computer routine designed to accomplish a job previously done by hand, the efficient use of FLIOP requires a period of preparation within the potential using organization. Specifically, the human time and effort saved by any such computer routine has to be used efficiently or the primary value of such a tool is wasted. In

addition, since efficient computer use is also involved, FLIOP is most efficient when a large number of cases are handled in each "run."

IV. POSSIBLE FUTURE APPLICATIONS OF FLIOP

It will be noted in the preceding paragraphs that FLIOP is not designed to automatically plan "missions" or over-all "aircraft utilizations." It is designed, however, so that, in addition to its utility to the human planner, it can be used with any computer program designed to solve certain of the more comprehensive mission problems. An exploratory development of computer routines directed toward the solutions of the "route selection" and "task objective" type of problem is currently in progress.

Finally, because FLIOP is designed to answer detailed questions about a given flight, the FLIOP output should be viewed as a detailed description of the limiting conditions which must be met to make a flight feasible. Unless it coincides precisely with the planner's desires relating to that flight, the FLIOP output is not a flight plan in the conventional sense, but rather a demonstration that a feasible flight plan can be calculated.

PART TWO

I. GENERAL DESCRIPTION OF FLIOP

The basic concept of FLIOP is the rapid, automatic integration of the following major factors:

a. The performance characteristics and limitations of a specific aircraft type. (See Appendix A for a description of the FLIOP calculation of Aircraft Performance.)

b. The meteorological phenomena which affect an aircraft's inflight performance. (See Appendix B for a description of Climatological Data Tables and their use in calculating the effect of winds on the planned flight.)

c. The physical and meteorological characteristics of the takeoff base which may affect and limit an aircraft's performance. (See Appendix C for a description of the Base Table.)

d. An outline of the plan which the user wishes to have calculated. On the Flight Outline Plan form, the user indicates the aircraft type for which the plan is required, the desired route, the constraints to be considered during the calculation and, possibly, the sequence in which certain constraints may be relaxed in an attempt to arrive at a feasible flight plan.

The basic concepts used internally in FLIOP are those of a <u>flight</u>, of <u>points</u>, and of <u>legs</u>. A flight is the operation of an aircraft from takeoff to landing or a continuous portion of any such operation. An aircraft operation in which an intermediate landing and takeoff occurs, for example, a staging operation, must be treated as two distinct FLIOP

flights. At a "point" some particular event occurs in the course of the flight. A point might thus be a takeoff point, a navigational check point, a target point, a refueling point, a penetration point, etc. The interval between two successive points is called a "leg." Information concerning a leg is always given in connection with the point following that leg. For computational purposes, enroute climbs and inflight refuelings are each considered to occur at a point. Provision is made to take into account that these are actually enroute activities starting at the point.

II. THE ELEMENTS OF THE FLIOP CALCULATION

The basic operation of FLIOP is the calculation of fuel expenditure and time. Within FLIOP there are many capabilities to solve various detailed problems relating to the operation of the aircraft at the "points" and along the "legs" of a given flight. The calculation of a flight plan is, in a sense, the combination of the solutions to the many "points" and "legs" problems.

A. Point Calculations

1. Takeoff point. There are two general types of takeoff calculation in FLIOP. One computes the expected length of takeoff ground roll (and time and fuel used during this operation) when given the aircraft type, aircraft weight, the type of takeoff procedure and the elevation and temperature of the takeoff base. FLIOP checks the expected ground roll so calculated against the length of runway available for takeoff. The second type of takeoff calculation computes the maximum feasible takeoff weight and fuel load when given the aircraft type, takeoff types, base elevation and temperature, and the length of runway available for

takeoff.

Specific takeoff types are represented in the FLIOP calculation as "takeoff modes."* Each "takeoff mode" is a set of parameters which describe the effect of aircraft weight, weight loss, fuel used, temperature and elevation on the ground roll, and other factors which affect the takeoff of a specific aircraft type using a certain type of takeoff procedure.

2. Refueling point calculations. For receiver aircraft there are two types of refueling point calculations. FLIOP can calculate the net gain in the receivers fuel load (and the net loss in enroute cruising time) when provided the receiver type, tanker type, and amount of fuel to be transferred. FLIOP can calculate the required amount of fuel to be transferred (and the net loss in enroute cruising time) when the receiver type, tanker type, and a required net gain in receiver fuel load is provided.

For tanker aircraft there are two types of refueling calculations. FLIOP can calculate the net loss in the tanker's fuel (and the loss in enroute cruising time) when the receiver type, tanker type, and required amount of fuel to be transferred in provided. FLIOP can calculate the amount of fuel which can be transferred (and the net loss in enroute cruising time) when the receiver type, tanker type and maximum allowable reduction in tanker fuel load is provided.

3. Turn points and navigation check points. A change in an aircraft's mode of flight, such as going from low altitude cruise to cruise climb, must in general be associated with a point, although in fact the

* See Appendix A for a description of FLIOP modes and their preparations.

change is only initiated at the point. FLIOP assesses a time and fuel penalty against the aircraft at a mode change point; to compensate for the actual time and/or fuel lost in the change, the magnitude of these penalties is dependent on the weight of the aircraft when it arrives at the point and the difference between the two modes.

4. Target points. FLIOP will subtract from the non-fuel weight of the aircraft any specified amount of weight at any point indicated.

B. Leg Calculations

There are two general types of "leg" calculations in FLIOP: "enroute legs" and "orbit legs." Specific types of leg calculations are described in FLIOP as "non-takeoff" modes.

A non-takeoff (inflight) mode is a set of parameters which describe the fuel consumption, altitude, airspeed, and other parameters of the aircraft operating in a specified manner, together with the variations in these quantities which may (or may not) result with changes in the aircraft's weight. For those modes in which an air refueling is permissible certain parameters are included to describe the effect of such an operation.

1. Enroute leg calculations. FLIOP solves for the fuel used and time elapsed on an enroute leg by calculating the effects of wind, flight mode, and weight on the aircraft type under consideration.

2. Orbit leg calculations. FLIOP calculates fuel used on an orbit leg by calculating the effect of mode and weight on the aircraft type under consideration for the time on orbit. (Under certain conditions FLIOP may be required to calculate the time on orbit as well as the fuel used.)

C. Flight Calculation

The planning operation is the combining of "point calculations" and "leg calculations" in a manner that permits the solution of problems presented to FLIOP. Each flight problem handled by FLIOP will have one "key problem" although many detailed problems have to be solved in arriving at a final result. "Key problem" is used to describe the major question in the FLIOP case which dictates the manner and order in which the point and leg calculations must be made. For example, the "key problem" of achieving a maximum attainable fuel reserve at destination requires point and leg calculations designed to achieve such a maximum.

In general, the FLIOP calculation can address itself to a key problem at the beginning of a flight, at the end of a flight, or in mid-flight. To achieve this capability FLIOP is able to calculate sequentially the flight legs and points backward from the end of flight or forward from takeoff. These calculation procedures are referred to in this paper as "backward motion" and "forward motion" respectively. A plan whose key problem is in mid-flight (for example, "What is the minimum amount of fuel a bomber must take on at the refueling point to fly the required flight?") requires both "forward motion" and "backward motion" calculations, a technique referred to here as "mixed motion."

In arriving at the solution to the basic time and fuel problem, FLIOP either calculates or uses certain information which may be of use to the planner or necessary to make the final output results meaningful. This information, as well as the result of some certain peripheral calculations (e.g., drift angles, ETAs, and total distances) are provided to the FLIOP user.

D. Priority Schemes

Included in FLIOP is an ability to input (on a semi-permanent basis) a set of priority schemes which add to the utility of the technique. A priority scheme is an ordered list of mode changes, drop tank options, and air refueling types. If the FLIOP user desires he may have FLIOP alter a given flight plan in the sequence indicated in a designed priority scheme until a flight has been computed that does not exceed the maximum allowable takeoff ground roll or takeoff gross weight and meets the minimum required fuel reserves at destination. This feature of FLIOP was developed so that the user can specify a desired policy related to "tradeoffs" between desired tactics and fuel expenditures (including inflight refuelings) and have FLIOP calculate its flights on that basis.

III. THE FLIGHT OUTLINE PLAN FORM

The flight outline plan form, a blank sample of which is shown as Figure 1, is the user's principal channel of communication with FLIOP. All instructions contained here must be very carefully followed since a single error can result in a completely erroneous calculation.

For each flight plan the FLIOP user wishes calculated, he must normally complete a Flight Outline Plan form. The first two lines of the form (each of which has its own set of headings) contains general information about the flight. The succeeding lines (which have a common set of headings) contain specific information about the individual points and legs of the flight. The remainder of this section is a detailed discussion of the individual fields in the Flight Outline Plan form. Unless otherwise indicated, the fields discussed must be completed.

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Mo	Wind percentile	Drop tank trmt	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol	Take off base: Runway length	Take off base: Sfty. fact	Take off base: Press elev	Take off base: Temp	

Location: Name symbol	Location: Lat	Location: Long	Wind components: Tail	Wind components: Cross	Distance	Non fuel off load	Air refuel: Type	Air refuel: F	Time on orbit	Pt Symbol	Mode	Control time	Degr fact	Control column
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	
		N											.	

FIGURE 1

Form 2
1-6-59

First Line

FLIGHT OUTLINE PLAN

ID		Mo.	Wind percentile	Drop tank trmt.		Aircraft type		Tactics priority scheme			D/T option point		D/T option time	
01–06	07	08–09	10–13	14–17	18	19–24	25	26–29	30	31–52	53–55	56–60	61–66	67–80

1. I.D. - Identification. Any six characters used to identify the resulting output plan.

2. Mo. - Month. Two digits indicating the month of the year to be used in wind and takeoff calculations.

3. Wind Percentile. Two digits indicating the desired probability that the aircraft making the flight will encounter more favorable winds than those used in the plan. Blank or 50 will result in mean winds being used.

4. Drop Tank Treatment. One of three symbols indicating desired handling of drop tanks in plan. No drop tanks, "-"; Carry drop tanks all the way, "+"; and release when no longer needed, "0" (zero). Enter "0" when an entry is made in "D/T Option Pt." or "D/T Option Time."

5. Aircraft Type. Six characters used to indicate type aircraft for which plan is made. B47EHW = Heavy weight version of "E" model of B-47. KC97G- = "G" model of KC-97 Tanker.

6. Tactics Priority Scheme. Four digits used to indicate the variations and their sequence which may be made in an attempt to arrive at a feasible plan. (At present "0000" (or blanks) indicates that no variations are allowed; "0001" = High altitude jet bomber flight; and "0385" = Low altitude jet bomber flight.)

7. D/Tank Option Point. Three characters indicating point symbol of point to which aircraft must carry drop tanks, releasing them as soon thereafter as they are no longer needed. Must be left blank when not applicable (i.e., when "-" or "+" are entered in item 4 above).

8. D/Tank Option Time. A plus or minus sign followed by five digits indicating relative time to which aircraft must carry drop tanks, releasing them as soon thereafter as they are no longer required. Must be left blank when not applicable.

Second Line

End of flight: Non fuel -D/ tanks		Fuel reserve		Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol		Runway length		Sfty. fact.		Press. elev.		Temp.	
1–6	7	8–13	14	15–20	21–28	29–34	35–36	37–42	43	44–48	49	50–52	53	54–58	59	60–62	63–80

1. Non Fuel - D/Tanks. Six digits giving the weight, in pounds, of the aircraft expected at the end of flight. This does include the basic weight, crew weight, and the weight of any other equipment carried throughout the mission. This does not include drop tank weight or weight of fuel reserve.

2. Fuel Reserve. Six digits giving weight, in pounds, of minimum acceptable fuel reserve at end of flight.

3. Refuel Points Fuel Reserve. Six digits giving weight, in pounds, of minimum acceptable fuel reserve of a receiver upon arrival at contact point with its tanker. May be left blank for tanker plans or plans having no refueling points.

4. First Point Fuel Reserve. Six digits giving weight of fuel, in pounds, on board aircraft at first point in Flight Plan. An entry is required if first point is other than a takeoff point and a "forward motion" calculation is indicated. If flight starting with takeoff has this number given here, it will be considered as the maximum allowable fuel on board at engine start.

5. Takeoff Base. (Omit if flight plan does not start with takeoff.)

   a. Name Symbol. Six characters, corresponding to symbol used in Base Table, used to indicate base from which takeoff is to occur.

   b. Runway Length. Five digit total length of runway in feet. May be omitted if base is listed in Base Table. Takeoffs planned for unlisted bases must have this entry, as well as "c," "d," and "e" below.

Second Line (Cont'd.)

Field		Card columns
End of flight	Non fuel -D/ tanks	1–6
	(shaded)	7
End of flight	Fuel reserve	8–13
	(shaded)	14
Refuel pts fuel reserve		15–20
	(shaded)	21–28
First pt fuel load		29–34
		35–36
Take off base	Name symbol	37–42
	(shaded)	43
Take off base	Runway length	44–48
	(shaded)	49
Take off base	Sfty. fact	50–52
	(shaded)	53
Take off base	Press. elev.	54–58
	(shaded)	59
Take off base	Temp.	60–62
		63–80

c. Safety Factor. Three digit safety factor. The percentage of the total length of runway that the aircraft may roll during takeoff. If left blank, 100% is used.

d. Press. Elev. Five digits giving pressure elevation, in feet, of the takeoff base. May be omitted if base name symbol is listed in Base Table and an entry has been made in month column of first line. If elevation is negative a minus sign replaces the first digit.

e. Temp. Three digits giving the temperature, in degrees F, of the takeoff base. May be omitted if name symbol is listed in Base Table and an entry has been made in the month column of first line. If the temperature is below $0^{o}F$. a minus sign is used in place of the first digit.

Note: If the user desires to use certain parameter (runway length, pressure elevation or temperature) of a base which differ from those given in the base table, he may specify any/or all of these numbers in the appropriate spaces and FLIOP will use them. Those left blank will be drawn from the base table. Thus, in FLIOP. the numbers written in the spaces on the Flight Outline Plan form "take precedence" over the numbers given in the tables.

Third and Succeeding Lines

Location: Name symbol		Location: Lat.	Location: Long.		Wind components: Tail	Wind components: Cross		Distance		Non fuel off load		[illegible] refuel: Type	[illegible] refuel: F		[illegible] on orbit		[illegible] Symbol		Mode		Control time		Degr. fact.	Control column
01–06	07	08–11	12–18	19	20–23	24–27	28	29–31	32	33–38	39	40	41–46	47	48–51	52	53–55	56	57–59	60	61–66	67	68–71	72–80
		N																					•	
		N																					•	

1. Location. (May be left blank if program is to calculate the required location or if line entry relates to an aircraft orbit.)

   a. Name Symbol. Six characters indicating a location name in "Location Table." May be left blank if line entries are made in latitude and longitude columns.

   b. Lat. Latitude of point in degree and minutes. (Example: 4123 - 41°23' north.)

   c. Long. Longitude of point in degrees and minutes. (Example: 04123E - 41°23' East.)

2. Wind Components. (May be left blank if entry has been made in month column and user wishes program to compute the wind components.)

   a. Tail. A plus or minus sign followed by three numerals indicating wind component velocity in knots. "+" indicates a component in the direction of flight. "-" indicates an adverse wind component.

   b. Cross. A plus or minus sign followed by three numerals indicating wind component velocity in knots. A plus sign indicates a wind from the right; a minus sign indicates a wind from the left.

3. Distance. A three digit number indicating the nautical miles from preceding point to point being listed. May be left blank if program is to compute distance.

4. Non-Fuel Off Load. Weight, in pounds, to be subtracted from aircraft weight at the point. Normally left blank except at weapon release points.

Third and Succeeding Lines (Cont'd.)

Name symbol		Location: Lat.	Location: Long.		Wind components: Tail	Wind components: Cross		Distance		Non fuel off load		Air refuel: Type	Air refuel: $\bar{F}$		Time on orbit		Pt Symbol		Mode		Control time		Degr. fact.	Control column
01-06	07	08-12	13-18	19	20-23	24-27	28	29-31	32	33-38	39	40-41	42-46	47	48-51	52	53-55	56	57-59	60	61-66	67	68-72	73-80
		N	|		|	|						|									|		•	
		N	|		|	|						|									|		•	

5. Air Refuel. (May be omitted if no refueling is planned for the point.)

a. Type. An alphabetic character indicating type of refueling calculation desired. "A" (or blank) = no refueling. "B" = maximum bomber type refueling (use only on receiver flight plans). "C" = minimum bomber type refueling (use only on receiver flight plans). "D" = fixed tanker type refueling (use only on tanker flight plans). "E" = maximum tanker refueling (use only on tanker flight plans). "F" = special indicator entered in column on last line of flight plan if "forward motion" is desired throughout the flight plan calculation.

b. $\bar{F}$. A six digit number indicating the requirement or capability of the other aircraft involved in the refueling. With "B" or "C" type refueling, $\bar{F}$ indicates tanker off load capability. With "D" it indicates the amount the tanker must off load. With "E" it indicates the receiver's minimum requirement. Left blank when special indicator "F" is used.

6. Time on Orbit. A four digit numeral indicating, in hours and minutes, the amount of time the aircraft is to orbit. (0241 = 2 hours and 41 minutes) When line entry is made in this column, location entries must be omitted. Entry of **** indicates a "free orbit" leg and the program will compute length of orbit (see "9. Control Time" below).

7. Point Symbol. Three alphanumeric characters used to designate the point at which the program is to comply with certain special instructions, for example, changes directed by priority scheme applications.

8. Mode. Three alphanumeric characters indicating the type of aircraft performance desired. The modes for the first point must be applied. Omission of an entry will result in the use of the mode designated for the preceding leg.

9. Control Time. A plus or minus sign followed by six digits indicating the relative time to be made good at that point. (Example: +01035 indicates a control time of 10 hours and 35 minutes after a relative, but not necessarily listed, zero hour.) If no control time is entered into this column for the flight, a +00000 control time is set at the first point of the flight. Insertion of a single control time results in the required time at that point being used as a reference time for the calculation of ETAs at all other points. Two or more control times can be specified. However, one (and only one) "free orbit" leg must appear between each two points having control times. (See "6. Time on Orbit" above.)

10. Degr. Fact. Degradation Factor. Three numerals, the third separated from the preceding two by the decimal, used to change the fuel consumption calculation for that leg by the indicated percentage. The degradation factor is used in cases where the aircraft under consideration has slightly different drag characteristics from the standard. (Example: The entry of 10.3 results in a range capability of 89.7% of standard.) An increase in range can be accomplished by changing the decimal to a comma. (Example: 09.3 results in a 9.3% increase in range capability.) Omission of any entry in this column results in "no degradation." The degradation factor does not affect the velocity calculation.

11. Control Column. One of two alphabetic characters or blank (normally left blank). An "E" is inserted in this column, on the line following the last line in a flight plan, to indicate the end of the input plan and to "trigger" the calculation. "T" is entered here to indicate a transfer card. Transfer cards are used in giving special instructions. (See Appendix D for a description of available "T" card applications.)

IV. THE OUTPUT 'ORM

The FLIOP output is designed to give a detailed picture of the planned flight by listing pertinent information at each point. An example of the output is given below with an explanation of the values listed under each heading. The output format can be changed to meet the requirements of the using organization.

```
  ID    TYPE   PRTY NO PERC ROLL  RUNWY SFTY  BASE  ELEV TEMP WT GND FU GND OPT TANKTIME
FIGUR2 B47EHW 0001 01  60  04386 11375  068 HUNTER 00350 063 152780 037920 DCP  +00211

  LOC     LAT    LONG    TAIL CRSS DFT  ALT   MODE  DF   TIME     ETA    DIST TDIST WEIGHT  FUEL  NF OFF FU OFF SYMBOL G
HUNTER 3201N   08107W                          #OT        0000   +00000             143780 034220                      A
        2900N  09000W   -068 +020 +02          101 06.5 0127   +00127  0492 00492 124560 015000        018790         B
        2900N  09500W   -065 -011 -01 34296    101 06.5 0044   +00211  0262 00754 134668 075108                DCP    A
                                      36963    101 06.5 0030   +00241             128429 020429                       A
        2900N  09637W   -061 +027 +03 37393    101 06.5 0016   +00257  0099 00853 126969 017969 010000               A
KELLY-  2922N  09834W   -049 -045 -06 39742    101 06.5 0022   +00319  0137 00990 113000 015000                      A
```

First Line

ID The same six characters input by the planner on the input form.

TYPE The aircraft type.

PRTY This is the point in the priority scheme at which FLIOP was able to complete the flight meeting all requirements.

MO Month. The month whose wind and base temperature was used.

PERC Wind percentile. The percentage probability that the aircraft in flying the planned flight will encounter more favorable winds than those used in the plan.

ROLL The number of feet the aircraft rolls during takeoff.

RUNWY The physical length of the runway in feet.

SFTY Safety factor. The input safety factor.

BASE Takeoff base name.

ELEV Takeoff elevation in feet.

TEMP Takeoff temperature in degrees F.

WT GND Aircraft weight in pounds at engine start.

FU GND Aircraft fuel in pounds at engine start.

OPT Drop tank option point symbol.

TANK TIME The time (ETA) at which the external fuel tanks were released.

If the FLIOP calculation reveals that the requested flight plan is infeasible, the last word in the first line will be "FAIL."

Second and Succeeding Lines

LOC	Location. The same name symbol that was input.
LAT	The latitude, in degrees and minutes, of the point.
LONG	The longitude (E or W) in degrees and minutes, of the point.
TAIL	The velocity, in knots, of the wind component parallel to the course of the aircraft. "+" being a component in the direction of flight, "-" being a component opposite the direction of flight.
CRSS	The velocity, in knots, of the wind component normal to the direction of flight. "+" being a wind from the right, "-" being a wind from the left.
DFT	Drift correction angle in degrees. "+" being a correction to the right. "-" being a correction to the left.
ALT	The altitude in feet of the aircraft at the point.
MODE	A symbol representing the manner in which the aircraft was flown on the leg ending at that point. (See Appendix A for fuller explanation of "mode.")
DF	Degradation factor. The input degradation factor for that leg.
TIME	The time, in hours and minutes, to fly the leg ending at that point.
ETA	The relative time, in hours and minutes, at the point calculated on the basis of the input relative time or times at one or more points.
DIST	Length of leg in nautical miles, ending at that point.
T DIST	Cumulative total distance in nautical miles to that point.
WEIGHT	The aircraft weight in pounds at that point.
FUEL	Fuel on board in pounds at that point.
NF OFF	Non-fuel weight in pounds off loaded at that point.
FU OFF	The weight of fuel in pounds transferred from tanker to bomber at that point.
SYMBOL	The input symbol for that point.
C	The type of refueling conducted at that point.

V. ILLUSTRATIVE APPLICATIONS OF FLIOP

Certain capabilities have been incorporated into FLIOP so that Flight Plans which embody certain "key problems" can be computed directly. Some of these applications were clearly in mind at the start of the FLIOP development. Others have been incorporated during development as the need for them became apparent and still others are either under current development or under consideration for future development.

A list of those currently available together with a brief description is given below. Appendix D contains a series of completed Flight Outline Plan forms and the resulting FLIOP outputs which are intended (1) to illustrate the various applications, (2) to serve as guides in the preparation of Flight Outline Plan forms, and (3) to serve as guides in the interpretation of flight plan information that FLIOP outputs.

A. Full Backward Motion Calculation

The flight plan in which the FLIOP user has indicated the end of flight weight and fuel load of the aircraft and has, in effect, asked the question, "What is the minimum fuel load with which the aircraft must start the flight so as to meet exactly the specified end requirement?" (See Example A, Appendix D for bomber application. See Examples D and I for tanker application.)

B. Full Forward Motion Calculation

A flight plan in which the FLIOP user has indicated the initial conditions of the flight and has asked the question, "How much fuel can the aircraft have on board at end-of-flight?" (See Example B, Appendix D.)

D. Mixed Motion Calculation

A flight plan in which the user has indicated the initial fuel

conditions and the final fuel conditions and has further indicated a refueling point at which the receiver may take on board enough fuel to satisfy the indicated requirements. (See Example C, Appendix D.) When mixed motion is applied to a tanke   craft, the question becomes, "Given the specified takeoff conditions and a specified fuel reserve at end-of-flight, how much fuel can this tanker off load?" (See Example E, Appendix D.)

D. A Priority Scheme

In this case the FLIOP user has described a flight pattern which may be beyond the capability of the aircraft but has indicated (by designating a certain priority scheme number) the sequence in which the flight plan conditions may be varied by FLIOP in an attempt to arrive at a feasible plan. The "key problem" in this application is, in effect, "How near to the input flight plan can this aircraft fly, still satisfying the indicated requirements at the start and end of flight?" (See Example F, Appendix D.)

E. Multiple Control Time

A flight plan in which the user has specified required times of arrival at two or more points along the flight. The FLIOP user is required to indicate one (and only one) "free orbit" point between every two control time points. The key question here is, "How long must the aircraft orbit at the 'free orbit' point to make good the required control times?" (See Example H, Appendix B.)

F. Cross Talk

This application requires that FLIOP "remember" certain data developed in one flight plan calculation and insert it into the appropriate place in

some succeeding flight plan (or plans). The instruction here is, in effect, "The flight plan for aircraft B is dependent upon something developed in the flight plan for aircraft A; transfer the information when it is developed."

1. ETA/Control Time Cross Talk. See Examples H and I, Appendix D. "T" card "-0023" used for "ETA to storage." "T" card "-0024" used for "Storage to Control Time."

2. Bomber to Tanker (or Tanker to Bomber) Fuel Transfer Cross Talk. See Examples E and F, Appendix D.

G. Break Point Application

By using this application the FLIOP user can describe a "basic" flight plan, follow this with another flight plan and ask the question, "At what point along the route described in the 'basic' flight plan does the aircraft lose its capability to 'break away' and complete the second flight plan?" (See Example G, Appendix D.) ("T" card "-0021" is used for break point application.) By describing a basic flight plan in which the aircraft, after following a specified route, is directed to proceed to an impossibly distant "break point," drop its bomb load and then return to a landing base, the planner can ask the question, "Given the specified prior route and conditions and given the specified return route and fuel reserve at destination, how far (in the direction of the remote break point) can this aircraft carry its bomb load?" (See Examples G and J, Appendix D.)

H. Deviation Time

(See Example K, Appendix D.) ("T" card "-0020" is used for this application of FLIOP.) By using this application the FLIOP user can

describe a "basic" flight plan, follow this with another flight plan and indicate a time (on the basic route) for the aircraft to deviate to the second flight plan. The question here is, "If the aircraft deviates from the basic plan at the specified deviation time, how much fuel will it have on board at the end of the second flight route?" A procedure is available which allows automatic repetition of this question with a specified changing of deviation times. (FLIOP must be run in forward motion for this application.)

VI. OPERATIONAL CHARACTERISTICS OF THE FLIOP COMPUTER ROUTINE

FLIOP is coded for use on an IBM 704 with 32,768 words of core storage. With minor modifications, FLIOP can be made to work on an IBM 709 or 7090 or on a 704 with 8,192 words of core storage. The remainder of this section concerns the use of FLIOP with a 704.

The basic on-line machine requirements for using FLIOP are two tape units and a card reader and either a third tape unit or printer. FLIOP input cases may be read in from either cards or tape; if input is from tape another tape unit is required.

The six console sense switches serve the following functions:

1. up - input FLIOP cases from tape
   down - input FLIOP cases from cards

2. up - output to tape for off-line printing
   down - output to printer

3. down - stop between cases
   up - normal, no interruption of cases

4. not used

5. down - output to tape for off-line punching (switches 2 and 6 must be down)
   up - output depends on switch 2

6. down - additional output with each case (used for debugging purposes)
   up - normal output information

The timing for a FLIOP case depends on many factors, the main five being the following:

1. The number of legs in the case
2. Card or tape input
3. Printer or tape output
4. Use of priority scheme

and 5. Position of meteorological tape at the beginning of the case.

If a case is run using tape input, tape output, and no priority scheme and the meteorological tape is positioned correctly, it should take roughly three seconds. For a case with, say, fifteen points, add to the on-line 704 time five seconds for card input, ten seconds for on-line printing, half a second for each priority category used, and five seconds for each month of data read to position the meteorological tape correctly. Thus it is desirable to run all cases using the same month at one time if it is convenient to do so.

If, due to some input or computer error, the computations for a case cannot be made, an error output will be made instead of the normal output. This error output consists of two lines, the first containing the ID for the case and the words ERROR ERROR ERROR and the second line the contents of index registers four, two and one, in that order, in negative and positive form. The negative location of index register four when looked up in the assembly listing for FLIOP should, in most cases, give the reason for the error for the case. For such errors as the case ID being left blank or a takeoff base being used that does not appear in the base

table this is true. Such errors, however, as caused by incorrect key punching of the input cards or as the use of two minimum bomber refuelings in one flight would probably not be indicated correctly by index register four.

Various special functions, such as various tape control functions, are controlled by means of "T cards" (cards or card images on tape with a T in column 72).

APPENDIX A

AIRCRAFT PERFORMANCE

I. GENERAL

The major factor in the calculation of aircraft performance is the weight change due to certain types of operation, such as takeoff, cruise, maximum endurance operation, high speed operation, etc. Associated with some of these types of operations are certain characteristics and restrictions, such as air velocities as affected by aircraft weight, maximum allowable weight, maximum fuel capacity, etc. In addition, there may be a number of different ways (modes) an aircraft can accomplish each of these operations and possibly a relative "cost" (mode change penalty) in going from one type to another. Finally, the aircraft may alter its weight during operations for reasons other than fuel consumption. In-flight refueling and weapon release are examples of the latter.

This Appendix is devoted to a discussion of the formulas used in FLIOP in computing aircraft performance, a listing of the parameters needed in such computations, and a description of how such parameters can be developed.

It is recognized that the results of a FLIOP calculation do not precisely describe the way a given aircraft may actually fly a desired mission. The results of a FLIOP calculation do, however, indicate that the required flight is feasible and that a detailed flight plan can be computed.

Organizations planning to use FLIOP must exercise considerable care in the development of aircraft performance parameters as these represent

more than the physical characteristics and limitations of the aircraft concerned. They also describe many of the operational policies and planning factors associated with the aircraft by the using organization. For example, an organization using an aircraft may wish to have a lower maximum allowable weight than that described in the technical publications of the aircraft manufacturer.

The detail used here in the discussion of certain FLIOP procedures and the concepts behind them, is conditioned by the assumption that organizations using FLIOP will have personnel familiar with conventional techniques of calculating aircraft performance. The detail used in the discussion of "unconventional" procedures and concepts used in calculating aircraft performance is considerably greater than in those sections in which "conventional" methods have been used.

II. TAKEOFF

The discussion in subparagraphs A, B, and C below relate to the development of a single given takeoff mode. The required parameters must be developed for each possible takeoff mode.

A. The formula used in FLIOP for the calculation of takeoff is as follows:*

---

*The authors wish to express their appreciation to R. B. Johnston for providing this formula.

$$R = [K_1(W + K_2)^2 - K_3][\frac{t+460}{520}]^{K_4} [1 - 6.87\times10^{-6} h]^{K_5}$$

where: W = aircraft gross weight at start of ground roll

t = ambient air temperature in degrees F

h = NACA pressure altitude, of the base above sea level, measured in feet

R = the runway length, measured in feet, used or allotted for takeoff

K_1, K_2, K_3, K_4, and K_5 are mode parameters to be determined by curve fitting techniques. K_1 is measured in feet per square pound, K_2 in pounds, and K_3 in feet. K_4 and K_5 are, of course, pure numbers.

Using the above formula, FLIOP can calculate the ground roll when given the aircraft weight, base temperature and base pressure elevation for a specific aircraft type (e.g., B47EHW) taking off in a particular manner (mode). (Example: Drop tanks installed, thrust augmentation fluid and eighteen ATO bottles being used.)

Conversely, FLIOP can calculate the aircraft weight at takeoff when given runway available for takeoff ground roll, base temperature, base elevation and mode, by solving the above equation for W.

B. The translation of aircraft weight on the ground to fuel load and the need to describe certain limitations require the inclusion in FLIOP of the following parameters:

Drop Tank Wt. - the weight, in pounds, of the external fuel tanks when empty (includes weight of trapped fuel)

Drop Tank Cap. - The weight, in pounds, of the fuel which can be carried in the external fuel tanks (excluding trapped fuel)

Capacity - The total fuel capacity, in pounds, of the aircraft in that mode (exclusive of trapped fuel)

Max. Ground Wt. - The maximum number of pounds that the aircraft is allowed to weigh on the ground for that takeoff mode. This weight must be the smaller of the following two quantities:

a. The maximum allowable weight on the ground of that aircraft type

b. The maximum allowable inflight weight for that aircraft plus the weight (both in fuel and otherwise) expended between the start of engines and the completion of the takeoff ground roll.

DELWT - The weight, in pounds, that the aircraft will lose (other than fuel expenditures) between "start engines" and "break ground."

DELWP - The total weight, in pounds, that the aircraft will lose (both the fuel expenditure and otherwise) between "start engines" and "break ground."

Max Roll - The maximum distance, in feet, that the aircraft can be permitted to roll during takeoff. Certain aircraft, when using thrust augmentation fluid during takeoff, are required to reserve some amount of this fluid for the acceleration phase which follows takeoff. The maximum ground roll can be used to reflect this limit. Certain conventional engined aircraft, in addition to having a maximum allowable ground weight, have a "maximum equivalent gross weight" (a parameter in which actual weight, temperature and pressure elevation is considered). The maximum ground roll can be used to reflect this limit also.

LTEMP - The minimum temperature, in degrees Fahrenheit, at which thrust augmentation fluid can be used during takeoff. (Note: If the FLIOP user indicates a takeoff using "water" and the base temperature is lower than the LTEMP, FLIOP will automatically change to a "dry" takeoff.)

C. The "K" factors required for each takeoff mode are obtained by developing a table of ground rolls for that mode in which the elevation, temperature, and aircraft weights have been varied within practical limits. The takeoff nomograms, included in the performance supplements of each aircraft handbook, is a convenient source for this information. Having developed such a table, a fitting procedure is used to develop the K factors.*

D. It can be seen that a number of takeoff modes may be required to describe the varied takeoff characteristics of an aircraft (for example, drop tanks on, drop tanks off). In addition, augmented takeoff, "dry" takeoff, full rocket assisted takeoff (RATO), partial RATO, full afterburner, etc., can all affect the takeoff characteristics and may require the development of takeoff modes. The following B-47 takeoff modes, currently in FLIOP, are listed for illustration. In this "mode code" the "-" indicates "no drop tanks," "+" indicates "drop tanks," "W" indicates "wet takeoff," "D" indicates "dry takeoff," the number "0" indicates "no ATO bottles used," "1" indicates "18 ATO bottles used," "2" indicates "30 ATO bottles used." The T indicates a takeoff mode.

+D0T	+W0T
-D0T	-W0T
+D1T	+W1T
-D1T	-W1T
+D2T	+W2T
-D2T	-W2T

Section V of Appendix A has a more detailed description of mode codes.

---

* A "fitting" routine, coded for the IBM 704, is available. (This routine was developed in the Plans and Automation Branch, Control Division, Directorate of Operations, Headquarters, SAC.)

E. In addition to the calculation of takeoff ground roll (or takeoff weight when ground roll is given), FLIOP has a certain capability to make a selection between the takeoff modes it will use. The presence or absence of drop tanks (+ or -) during takeoff may be controlled by the FLIOP user or may, if desired, be altered by the priority scheme being used. A "wet" takeoff will automatically be changed to a "dry" takeoff if the base temperature is lower than the "LTEMP," however the reverse is not true. The use of no ATO, partial ATO and full ATO should be listed in the FLIOP aircraft performance table in that order (see the B-47 mode code above). In calculating a "forward motion" takeoff, FLIOP will use not only the takeoff mode listed but also those modes which have a lesser number of ATO bottles. The takeoff mode which results in the maximum amount of fuel at takeoff is then used in the flight plan being computed. In a "backward motion" takeoff the minimum required number of ATO bottles is computed.

XII. NON TAKEOFF (INFLIGHT MODES)

Several formulas are required for the computation of flight altitude, fuel consumption (range), and refueling factors for inflight modes. A technique is provided for varying the air velocity as a function of weight when applicable. Finally, certain limitations on weight and fuel load must be listed. Each of these will be discussed in considerable detail in the succeeding paragraphs. The reader is again reminded that these factors do not necessarily represent the maximum capabilities and limitations of the aircraft concerned in the specific mode under consideration. Rather they represent the capabilities and limitations that the

FLIOP using organization decides, as a matter of policy, are appropriate for purposes of planning. Subject to this type of modification, the most convenient source of the data required for mode preparation is the appropriate aircraft flight handbook.

A. Range

(1) Two different formulas are used in FLIOP to calculate the range/aircraft weight change relationship. The first, used when there is a linear relation assumed between range and aircraft weight change, is:

$$R = C_o (W_1 - W_2)$$

or equivalently

$$\frac{dW}{dR} = \frac{1}{C_o}$$

where: R = air distance, in nautical miles, during a change in aircraft gross weight from W_1 to W_2 pounds.

$\frac{dW}{dR}$ = the "instantaneous fuel consumption rate in pounds per nautical air mile.

C_o is to be determined by a fitting process and is measured in nautical miles per pound.

(2) The second range/weight change formula, used when there is a logarithmic relationship assumed between range and aircraft weight change, is:

$$R = C_o \log_e \left(\frac{W_1 + C_1}{W_2 + C_1}\right)$$

or equivalently

$$\frac{dW}{dR} = \frac{W_1 + C_1}{C_o}$$

where: R = air distance in nautical miles, during a change in aircraft gross weight from W_1 to W_2 pounds.

$\frac{dW}{dR}$ = instantaneous fuel consumption rate measured in pounds per nautical mile.

C_0 and C_1 are to be determined by a fitting process. C_0 is measured in nautical miles and C_1 is measured in pounds.

It will be recognized that the above formula is a modification of the Breguet type approximation, in which C_0 and C_1 are used to give a more accurate description of lift-drag ratio than a fixed single constant. An indicator must be included in each set of specific mode parameters to designate which of the above formulas are to be used in that specific mode. A symbol, designated C_2, is included to serve as the indicator. C_2 "-" indicates the nautical mile per pound (unaffected by weight) formula. C_2 "+" indicates the modified Breguet type approximation.

The C_0 and C_1 factors are the most critical input numbers in FLIOP. A seemingly minor inaccuracy can result in a significantly inaccurate portrayal of an aircraft's range capability (fuel consumption) over a long flight being computed by FLIOP. They are developed by fitting the range curves given in the appropriate aircraft's flight handbook. Two such fitting procedures are outlined below. It is recommended that both be used and that the result be carefully checked before the resulting C_0 and C_1 factors are incorporated into the FLIOP aircraft performance table. Further, it is important that the C_0 and C_1 factors developed achieve their greatest accuracy in those aircraft weight regimes which are known to include the usual aircraft weights for the mode under consideration.

B. Altitude

Two different formulas are used in FLIOP to calculate the

altitude/aircraft weight relationship. The first, used when there is no such relationship assumed (the aircraft flies at a fixed, designated altitude regardless of weight), is:

$$H = H_0$$

where: H = pressure altitude measured in feet (NACA standard atmosphere).

In such a case, H_0 is simply the designated altitude of flight for the mode.

The second altitude/aircraft weight formula,* used when the aircraft increases flight altitude as its weight decreases, is:

$$H = H_0 + H_1 \log_e W$$

where: W = aircraft gross weight in pounds

H = pressure altitude measured in feet (NACA standard atmosphere)

H_0 and H_1 are to be determined by fitting and are measured in feet. An indicator must be included in each specific set of mode parameters to designate which of the above formulas is to be used: H_2- indicates a constant altitude mode, H_2+ indicates a variable altitude mode.

---

* A "fitting" routine, coded for the IBM 704, is available. (This routine was developed in the Plans and Automation Branch, Control Division, Directorate of Operations, Headquarters, SAC.)

C. Air Velocity

Incorporated into the FLIOP aircraft performance table for each mode is a provision for approximating a variation of the aircraft's air velocity as the aircraft's weight varies. Six quantities, labeled WBAR1 through WBAR6, are included to bracket five aircraft weight bands. WBAR1 represents the lowest weight and WBAR6 the greatest. Associated with those five weight bands are five quantities labeled V1 through V5. The parameter V1, ..., V5 are measured in nautical miles per minute. V1 is the aircraft's air velocity in knots that will be used by FLIOP when the aircraft's weight is between WBAR1 and WBAR2; V2 is the velocity used between WBAR2 and WBAR3, etc. Conventionally WBAR1 is listed as being zero, WBAR6 as being an impossibly high weight. When the mode is one in which the aircraft has a fixed velocity, that velocity can be listed for V1 with zero listed for WBAR1 and the impossibly high weight listed for WBAR2.

D. General Weight and Fuel Criteria

The following values must be listed in each inflight mode carried in a FLIOP aircraft performance table:

(1) Drop Tank Wt. - the empty weight, in pounds, of the external releaseable fuel tanks including weight of trapped fuel

(2) Drop Tank Cap. - the fuel capacity, in pounds, of the external fuel tanks excluding weight of trapped fuel

(3) Capacity = the total fuel capacity of the aircraft, in pounds, in the mode under consideration excluding the weight of trapped fuel

(4) Max. Fly Wt. - the maximum allowable inflight weight of the aircraft, measured in pounds.

E. Inflight Refueling (Receiver)

The calculation of air refueling in FLIOP is made on the basis of equivalent effects. An actual refueling operation, for a receiver aircraft, will encompass all or most of the following separate operations:

(1) Descent to rendezvous phase

(2) Chase phase

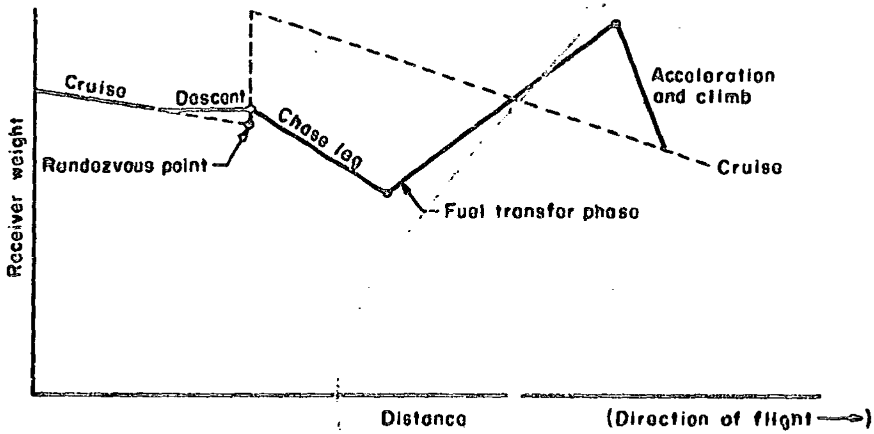
(3) Refueling phase

(4) Acceleration and climb.

Each of these phases may produce, in the bomber, a fuel consumption and velocity at variance with those that FLIOP might calculate for a non-refueling leg in the same mode. FLIOP accounts for these "off-mode" effects by calculating the equivalent weight which the receiver must theoretically have, the instant it passes the rendezvous point, to fly in the past refueling point mode and arrive at the actual end of refueling operation at the same weight as the actual expected weight. The following diagram of weight change versus distance is designed to indicate this concept. The actual refueling is indicated as a solid line. The FLIOP calculation as a dashed line. The abrupt vertical rise of the dashed line in this diagram is the FLIOP applied weight difference (WD) required to produce coincidence of the FLIOP aircraft weight and actual aircraft weight at the end of the complete refueling operation. The amount of weight difference (WD) to be applied is calculated in FLIOP by the following formula:

$$WD = WD0 + WD1 \text{ (tanker off load)}$$

It can be seen from the diagram that the actual weight of the receiver aircraft during the refueling is at its highest point at the end of the


Cruise
Descent
Chase leg
Acceleration and climb
Cruise
Rendezvous point
Fuel transfer phase
Receiver weight
Distance
(Direction of flight ⟶)

fuel transfer phase. To insure that the receiver aircraft does not exceed its maximum allowable inflight gross weight or fuel capacity during the actual refueling operation, FLIOP applies the following formula:

$$E = EO + E1 \text{ (tanker off load)}$$

E is added to the weight of the receiver gross weight and fuel capacity at the rendezvous point and the results compared against the maximum allowable weight and fuel capacity.

Since the air velocities achieved by the receiver aircraft during the actual refueling phases may vary from the FLIOP computed velocity of the receiver aircraft (in the post-refueling mode), a "time penalty" must be imposed on the "FLIOP Aircraft" so that its expected time of arrival at the end of refueling point coincides with the arrival of the actual aircraft. This "Time Penalty" (TAU) is also related to the amount of fuel off loaded by the tanker. The following formula is used:

$$TAU = TAUO + TAU1 \text{ (off load)}$$

In the development of the necessary parameters (WDO, WD1, EO, E1, TAUO, and TAU1) the expected values of weight difference (WD), E, and TAU for a varied series of tanker off loads must be computed and the results plotted. The appropriate parameters can then be computed by a simple fitting technique. It has been found convenient to compute all of the expected values together using a format similar to that shown below. Theoretical values are indicated by "T." Note that a different tanker type can produce a requirement for different refueling parameters in a specific receiver's mode. An additional mode, with an appropriate

1. Actual receiver wt. at end fuel transfer (conventionally the max. inflight wt.)						
2. Wt. of fuel transferred						
3. Time elapsed in transfer						
4. Distance covered during transfer						
5. Fuel used during transfer						
6. Wt. of receiver at start of transfer (1 + 5 + 2)						
7. Fuel used during chase						
8. Time elapsed in chase						
9. Distance covered in chase						
10. Receiver wt. at start of chase (6 + 7)						
11. Fuel used in descent						
12. Time elapsed in descent						
13. Distance covered in descent						
14. Receiver wt. at start of descent (10 + 11)						
15. T fuel used in pre-refueling mode to fly distance 13						
16. T time used in pre-refueling mode to fly distance 13						
17. T aircraft wt. at refueling point (14 - 15)						
18. Actual wt. of receiver at end of fuel transfer (same as 1)						
19. Fuel used in climb						
20. Distance covered in climb						
21. Time elapsed in climb						
22. Receiver wt. at end of climb (18 - 19)						
23. T fuel used by receiver (in post-refueling mode) to fly distance 20+9+4						
24. T fuel elapsed in flying (in post-refueling mode) distance 20 + 9 + 4						
25. T receiver wt. at depart refueling point (22 + 23)						
26. Specific "WD" (25 - 17)						
27. Specific "E" (18 - 17)						
28. Specific "TAU" [(3 + 8 + 12 - 16 + 21) - 24]						

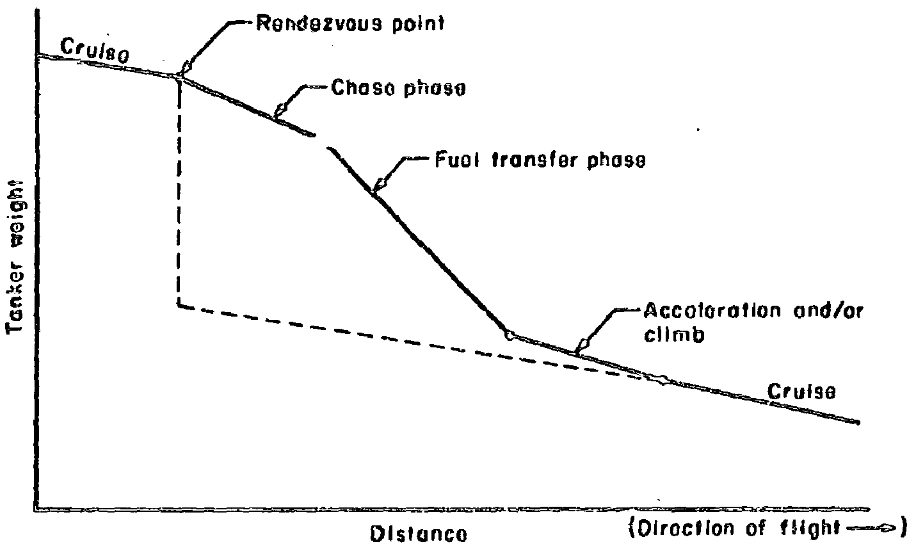
indicator, must be developed and inserted in the receiver's aircraft performance table to reflect this situation.

F. Inflight Refueling (Tanker)

The calculation of the effect of inflight refueling on the tanker is quite comparable to the calculation made for the receiver except that E0 and E1 are not applicable (the tanker cannot exceed its maximum allowable inflight weight during the operation as it can only lose weight). The tanker weight change versus distance diagram below is designed to depict the actual and the "FLIOP" situations. The actual refueling is indicated by a solid line; the FLIOP calculation by a dashed line. The abrupt vertical descent of the dashed line in the diagram is the FLIOP applied weight difference "WD" required to produce coincidence of the FLIOP aircraft weight and actual aircraft weight at the end of the complete refueling operation. The amount of WD which is to be assessed against the tanker is computed using the same formula used for calculating similar data for the bombers [i.e., WD = WD0 + WD1 (off load)]. The format shown has been found to be convenient in the preparation of the tanker's WD parameters.

IV. MODE CHANGE PENALTIES

When an aircraft, during a flight, changes from one mode of operation to another there may be a period during which the fuel flow and air velocity differ from those of the second mode. Take, for example, an aircraft that is cruising at sea level (or has just taken off) and a change of mode to cruising at altitude is indicated. The fuel used and the time elapsed during the actual climb will be greater than the


Rendezvous point
Cruise
Chase phase
Fuel transfer phase
Tanker weight
Acceleration and/or climb
Cruise
Distance
(Direction of flight →)

1. Actual tanker wt. at rendezvous						
2. Distance covered in chase						
3. Fuel used in chase						
4. Actual tanker wt. at contact (1 - 3)						
5. Distance covered in transfer phase						
6. Fuel used by tanker during transfer						
7. Fuel off load						
8. Tanker wt. at end of transfer (4 - 6 - 7)						
9. Distance covered in acceleration and climb						
10. Fuel used in acceleration and climb						
11. Tanker wt. at end of climb (8 - 10)						
12. T fuel required (at wt. 14) to fly distance 2 + 5 + 9						
13. Theoretical tanker wt. at rendezvous point (11 + 12)						
14. Specific WD (1 - 13)						

Note that a different receiver type can produce a requirement for different refueling parameters in a given tanker mode. An additional mode must be developed to reflect this situation.

theoretical fuel and time used to cruise at altitude for the "climb distance." FLIOP allows for this effect by assessing appropriate time and fuel penalties against the aircraft at the mode change point, the amount of the penalties being dependent on the aircraft weight. Some mode changes do not require penalty assessments. The formulas used to calculate these quantities are as follows:

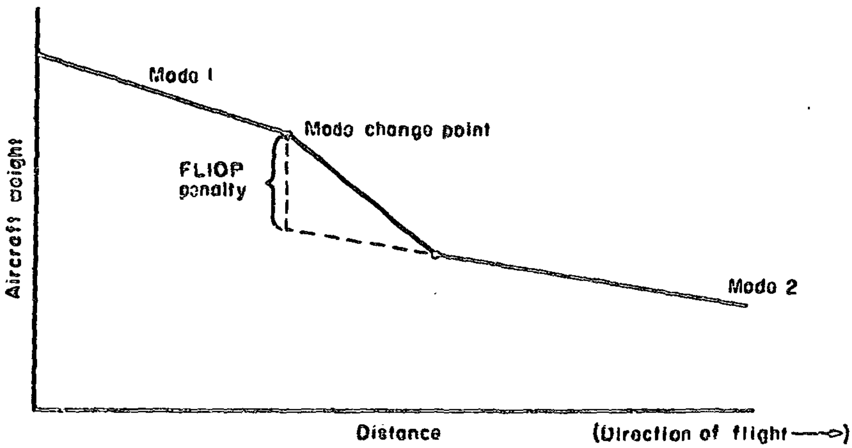
(1) Time penalty

TAUP = TAUPO + TAUP1 (aircraft weight)

(2) Weight penalty

PEN = PENO + PEN1 (aircraft weight)

The following diagram is intended to illustrate this concept of fuel penalties. The actual aircraft data is shown as a solid line; the FLIOP calculation by the dashed line. Penalty assessments are not required between all mode combinations (for example, penalties are not appropriate when an aircraft changes mode from maximum speed to cruising speed). Further, FLIOP does not assess negative penalties (for example, the actual small gain in fuel when an aircraft changes from cruise at altitude to cruise at sea level). However, for all mode change combinations which do have significant penalties, appropriate penalty parameters must be developed and included in the FLIOP aircraft performance table. It has been found convenient to use the format given below to calculate specific PEN's and TAUP's and fit these to derive the appropriate PENO, PEN1, TAUPO and TAUP1 parameters.


Mode I
Mode change point
FLIOP penalty
Mode 2
Aircraft weight
Distance
(Direction of flight ——>)

1. Aircraft wt. at mode change point							
2. Distance covered in mode change							
3. Fuel used in mode change							
4. Time elapsed in mode change							
5. Actual aircraft wt. at end of mode change (1 - 3)							
6. Theoretical fuel used (in mode 2 at aircraft wt. 5) over distance 2							
7. Theoretical time elapsed (in mode 2 at wt. 5) over distance 2							
8. Theoretical aircraft wt. at mode change point (5 + 6)							
9. Specific PEN (1 - 8)							
10. Specific TAUP (4 - 7)							

V. DEVELOPMENT OF A MODE CODE

A. General

The number and types of modes for a given type aircraft which may be developed and included in FLIOP, is largely dependent on the needs of the using organization. It has been found advantageous, however, to restrict the number and types developed to the minimum necessary to develop adequately the required plans. A large number of basically similar modes can be a source of confusion to both the person completing the Flight Outline Plan form and the reader of the resulting flight plan. This "practical limitation" has not been found to be a serious one, as the mode codes listed below for the B-47 and KC-97 should indicate. The list below indicates only those mode symbols which the user normally places in the mode symbol column of the Flight Outline Plan form (or reads in the mode column of the printed flight plan). Mode parameters for the aircraft concerned, with and without drop tanks installed ("+" and "-" respectively) must be developed and listed in FLIOP. However, the user has access to this variation via other input techniques.

B-47 Mode Codes

DOT - Takeoff, no ATO bottles, no water
D1T - Takeoff, 18 ATO bottles, no water
D2T - Takeoff, 30 ATO bottles, no water
WOT - Takeoff, no ATO bottles, water
W1T - Takeoff, 18 ATO bottles, water
W2T - Takeoff, 30 ATO bottles, water
000 - Maximum range power settings at sea level
010 - Maximum speed power settings at sea level
001* - Maximum range power settings at optimum altitude (if used on a refueling leg, the tanker is a KC-97)
101* - Maximum range power settings at optimum altitude (if used on a refueling leg, the tanker is a KC-135)
0E1* - Maximum endurance power settings at optimum altitude (if used on a refueling leg, the tanker is a KC-97)
1E1* - Maximum endurance power settings at optimum altitude (if used on a refueling leg, the tanker is a KC-135)
011 - Maximum range at normal rated thrust, optimum altitude

KC-97 Mode Codes

WOT - Takeoff using thrust augmentation fluid
001 - Maximum range power setting at 5,000 ft. altitude
0E1 - Maximum endurance power setting at 5,000 ft. altitude
002 - Maximum range power setting at 10,000 feet altitude
0E2 - Maximum endurance power setting at 10,000 feet altitude
003* - Maximum range power setting at 15,000 feet altitude
0E3* - Maximum endurance power setting at 15,000 feet altitude
004 - Maximum range power setting at 20,000 feet altitude
0E4 - Maximum endurance power setting at 20,000 feet altitude

---

*Refueling penalty parameters are included in FLIOP for these modes only. Therefore only these modes can be used on a leg immediately prior to and immediately following a refueling point.

B. The Mode Code Convention

(1) Jet Aircraft. From the illustration given above, it can be seen that a general convention is used in the labeling of modes. The first digit of the takeoff mode symbol has been used to designate the use or non-use of thrust augmentation fluid. The second (middle) digit has been used to indicate incremental use of ATO bottles and the third character is "T" (for takeoff).# The inflight mode symbols also follow a general convention. The first digit indicates the "co-refueler" type with "C" being used for a low performance "co-refueler." This space can also be used to indicate the presence or absence of externally carried "drag producers" (other than drop tanks) which may be carried and released in flight. The second digit of the jet aircraft mode codes is used to designate power condition (speed), with "E" representing endurance power settings, "0" representing cruise power settings, and "1" representing normal rated thrust power settings. The digit "2" can be used here to represent military rated thrust power settings if required. (The current FLIOP mode codes for the B-52 includes this mode.) The third digit of the jet aircraft mode code is an altitude indicator, with "0" being used to indicate sea level and "1" being used to indicate that the appropriate altitude for maximum range at the given power setting and aircraft weight.#

(2) Aircraft powered by reciprocating engines. From the KC-97 mode code illustration given above, it can be seen that a generally similar mode coding to that of the jets has been used. In the takeoff mode, the

In determining what mode change penalties, if any, are to be assessed, FLIOP checks only the third character in the two modes involved. This introduces a requirement for a distinction between the third character of two modes which, used sequentially, require the application of penalties.

first space is used to indicate the use or non-use of water. (At present only "wet" takeoff mode parameters are in the KC-97 mode table in FLIOP.) The second digit represents other takeoff assisting devices (more available for the KC-97), and the third character is "T" (for takeoff). The inflight modes for these aircraft use the first figure to designate the "co-refueler" type (since there appears to be no significant mode parameter difference for the KC-97 refueling a B-47 and the KC-97 refueling a B-52, only "O" appears in the above KC-97 mode code). The second character in the mode code represents power setting (speed) with "O" representing maximum range power setting and "E" representing maximum endurance power settings. The third character has been used as an altitude indicator with altitude available in multiples of 5,000 feet, "1" thus represents 5,000 feet, "2" ten thousand, etc.

Fixed altitude modes can be developed for jet aircraft and variable altitude modes (in which the altitude increases with aircraft weight reduction) can be developed for propeller driven aircraft if such applications are required.

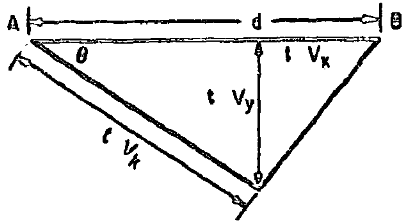
APPENDIX B

FLIOP WINDS AND NAVIGATION

I. THE FLIOP CALCULATION OF WIND EFFECTS

The effect of winds on an aircraft in flight can vary the leg speeds and enroute times in a manner which may be significant.

Provision has been made in FLIOP to permit the calculation of this effect. The following paragraph describes the FLIOP calculation of wind effect.



In the above figure, d represents the ground distance for a leg from A to B. V_k indicates the true air speed, t the time, V_x and V_y the tail and cross wind components respectively, and θ the drift angle. The plane flies at an angle θ from the line A B at an air* velocity V_k. The parameters d, V_k, V_x, and V_y are known for each leg. Before the fuel computations for each leg are made, the following two equations are solved for t and θ:

---

* Provision has been made for legs on which the air velocity is variable.

$$\sin \theta = \frac{V_y}{V_k}$$

$$t\, V_k \cos \theta + t\, V_x = d\ .$$

Thus the winds for a leg are part of the computation of the time, t, for the leg which in turn affects the air distance, $t\, V_k$. The air distance for the leg is the quantity used in the determination of the fuel used.

II. THE CALCULATION OF WIND COMPONENTS

It should be noted in the paragraph above that the FLIOP calculation requires that the wind be provided as cross wind and tail wind components. The FLIOP user may input, on the Flight Outline Plan form, the forecast wind components for each leg (or any leg) of a flight. Such a direct inputting technique might be used in planning flights in which forecast winds are available.

When using FLIOP as a tool in developing or studying future operations, seasonal wind data is normally used.

To provide the FLIOP user with a convenient method of inputting seasonal wind data, climatological data tables are incorporated in FLIOP. The data tables described here are those currently used in FLIOP. More data periods, a different data grid, and different atmospheric levels may be developed and used if required.

For each mid-season month [Jan (01), April (04), July (07), and October (10)] at the intersection of every five degrees of longitude and latitude from 20°N to 90°N, the following data* is provided:

* These data were prepared from information furnished by the 3rd Weather Wing, Headquarters, SAC, Offutt Air Force Base, Nebraska.

a. The mean elevations of the 700 MB, 500 MB, 300 MB, 200 MB, and 100 MB levels.

b. The standard vector deviation of the winds.

At 15°N, 10°N, 5°N and the equator, pseudo elevations of the millibar levels are provided. These pseudo elevations were determined by converting the east-west component of the mean wind between 20°N and 15°N into a pressure difference using the standard geostrophic wind approximation and applying this pressure difference to the 20°N data to obtain the pseudo 15° data. Calculation down to the equator was done by a step-by-step process at each 5 degrees of latitude. Since the geostrophic wind approximation has a term in which the sine of the mid latitude is used as a divisor, it was necessary to use sin 10° between 10°N and the equator to preclude a theoretical wind of infinite velocity crossing the equator. This factor and the general sensitivity of the wind calculation to even small pressure differences at low latitudes makes the use of current FLIOP wind tables inaccurate south of 10°N. <u>Any flight legs planned by FLIOP south of 10°N must have wind components inserted on the FLIOP input form</u>.

From the climatological data tables, FLIOP calculates the seasonal mean wind components in the following manner:

a. The desired period is determined by the program by the number inserted in the month column of the Flight Outline Plan form.

b. During the FLIOP calculation, which is made on a leg by leg basis, FLIOP computes the altitude of the aircraft on the leg, then interpolates in longitude, latitude and altitude from the wind tables to determine the elevation of the initial and end points of the leg. The difference between the elevations of the starting point and ending point

are used in the standard geostrophic wind formula to determine the cross wind component. A similar calculation is then made for the end points of a line of length equal to the leg, drawn normal to the leg, with the leg and the cross line bisecting each other. The result of this second calculation is used to determine the tail wind component. To achieve acceptable accuracy in wind computation, FLIOP automatically breaks any leg longer than 1,000 n.m. which requires wind computations into legs of 1,000 n.m. or less. When the planner has indicated that FLIOP is to use the mean seasonal wind, the cross wind and tail wind components so determined are used.

c. The standard vector deviation of the winds for the leg is obtained by FLIOP by averaging the standard vector deviation quantities at the initial and end points of the leg and those obtained from the two cross leg data points. Since the standard vector deviation quantity so obtained is an average point value, it is necessary to multiply this quantity by a factor which takes leg length into account. The factor currently used is obtained from a linear function which is 1 at 0 n.m. leg length, and .6 at 1,000 n.m. leg length. To convert the omnidirectional leg standard vector deviation so obtained into a component quantity, it is divided by $\sqrt{2}$. The quantity so determined is one standard component deviation.

When the planner has indicated, on the input form, a desired wind confidence percentile, FLIOP selects the appropriate number of standard deviations (based on an assumption of circular Gaussian distribution) and applies it to the tail wind component in such a manner that the result will be more or less favorable to the flight than the mean leg wind depending on whether the percentile is less or more than 50. Thus, an

input percentile of 85 will result in the use on each leg of such a wind that there is a statistical probability of .85 that the aircraft would experience more favorable winds.

The FLIOP user should be aware that the "wind percentile" calculation described above is made on each leg of a FLIOP flight. This "leg-for-leg" type calculation, in effect, assumes a perfect correlation of all enroute winds (an assumption known to be false). A procedure to approximate an "over-the-total-flight" wind confidence factor is under study. Until such time as an "over-the-flight" confidence calculation can be incorporated, the FLIOP calculation of winds (on the leg-for-leg basis) actually provides a considerably higher "over-the-total-flight" confidence factor than is indicated by the wind percentile figure.

APPENDIX C

BASE AND LOCATION TABLES

I. BASE TABLES

To calculate the expected takeoff ground roll for any aircraft type at a given weight, information on base temperature and pressure elevation is required. To insure that the computed ground roll does not exceed the allowable maximum, information is required on total runway length and the percentage of that length that the FLIOP user will allow ground roll to reach. All this data can be given to FLIOP by filling the "Takeoff Base" data section of the Flight Outline Plan form. An indication of maximum allowable percentage of runway length (safety factor) must be given in every case.

In planning the future operation of aircraft from many bases, it is usual to develop standard planning factors for temperature and pressure elevation for a number of periods of the year. Provision has been made in FLIOP to store a table of such planning factors. These data are then brought into the FLIOP calculation when required. The planner selects the correct data by indicating the base name symbol and month.

II. LOCATION TABLES

As a convenience to the planner, the geographical coordinates of locations frequently used in planning are stored in a table, each entry in the table being associated with a location symbol. By inserting the proper symbol in the name symbol column of the FLIOP input form, the planner can avoid the repeated determining and writing down of coordinates. All frequently used takeoff and landing bases are natural candidates for

inclusion in the location table.

III. BASE AND LOCATION NAME SYMBOLISM

The FLIOP user may select any six character symbol to represent the name of a base or location. In reducing base names to base and location name symbols, it has been found convenient to use a system of deletion of non-initial vowels (from right to left) followed by the deletion of consonants (from right to left) until six letters remain. Blanks are filled in by dashes. Thus Lakenheath is symbolized by LKNHTH, Eielson by EIELSN, Hunter by HUNTER, and Dow by DOW---.

Using organizations can develop their own base and location tables.

IV. AN ABBREVIATED LIST OF BASES AND THEIR ASSOCIATED NAME SYMBOLS

ADAK	ADAK--	COLUMBUS	COLMBS
ALTUS	ALTUS-	DAVISMONTHAN	DVSMNT
AMARILLO	AMARLL	DOVER	DOVER-
ANDERSEN	ANDRSN	DOW	DOW---
BARKSDALE	BRKSDL	DYESS	DYESS-
BEALE	BEALE-	EGLIN	EGLIN-
BERGSTROM	BRGSTR	EIELSON	EIELSN
BIGGS	BIGGS-	ELLSWORTH	WLLSWR
BLYTHEVILLE	BLYTHV	ELEMENDORF	ELMNDR
BURTONWOOD	BRTNWD	FAIRCHILD	FRCHLD
BUNKERHILL	BNKRHL	FORBES	FORBES
CARSWELL	CRSWLL	GLASGOW	GLASGW
CASTLE	CASTLE	GRANDFORKS	GRNDFR
CLINTONSHERMAN	CLNTNS	GREENVILLE	GRNVLL

GRIFFISS	GRFFSS	MOUNTAINHOME	MNTNHM
HICKAM	HICKAM	OFFUTT	OFFUTT
HOMESTEAD	HOMSTD	OTIS	OTIS--
HUNTER	HUNTER	PEASE	PEASE-
KADENA	KADENA	PINECASTLE	PNCSTL
KELLY	KELLY-	PLATTSBURG	PLTTSB
KINDLEY	KINDLY	PRESQUEISLAND	PRSQIS
KINROSS	KINRSS	RAMEY	RAMEY-
KIRTLAND	KRTLND	RANDOLPH	RNDLPH
KWAJALEIN	KWAJLN	ROBINS	ROBINS
LADD	LADD--	SAWYER	SAWYER
LAJES	LAJES-	SCHILLING	SCHLLN
LAKECHARLES	LKCHRL	SELFRIDGE	SLFRDG
LARSON	LARSON	SEYMOURJOHNSON	SYMRJH
LAUGHLIN	LAGHLN	SHEPPARD	SHPPRD
LINCOLN	LINCLN	SUFFOLKCOUNTY	SFFLKC
LITTLEROCK	LTTLRC	THULE	THULE-
LOCKBOURNE	LCKBRN	TINKER	TINKER
LORING	LORING	TRAVIS	TRAVIS
MACDILL	MACDLL	TURNER	TURNER
MALMSTROM	MLMSTR	WAKEISLAND	WKISLN
MARCH	MARCH-	WALKER	WALKER
MATHER	MATHER	WESTOVER	WESTVR
MAXWELL	MAXWLL	WHITEMAN	WHITMN
MCCHORD	MCCHRD	WRIGHTPATTERSON	WRGHTP
MCGUIRE	MCGUIR	WURTSMITH	WRTSMT
MINOT	MINOT-		

APPENDIX D

ILLUSTRATIVE APPLICATIONS OF FLIOP

This appendix is a series of completed Flight Operations Plan forms and the resulting FLIOP outputs. They are intended to illustrate the various applications of FLIOP, serve as guides in the preparation of Flight Outline Plan forms and illustrate the interpretation of the information FLIOP outputs.

For convenience the transfer ("T") cards used in various applications are tabulated below with an abbreviated description of their functions.

"T" card	Use
-0009	Transfer "F" to storage
-0010	Transfer "F" from storage to "F BAR"
-0023	Transfer ETA to storage
-0024	Transfer ETA from storage to Control Time Column
-0021	"Break Point" calculation
-0020	"Deviation Time" calculation

EXAMPLE A (EXMPLA)

Flight Outline Plan form

(1) In the first line the user has asked for a flight calculation using the April (04) takeoff base temperatures and such winds that an aircraft making the flight would have an 77 per cent probability of encountering less adverse winds than those used in the plan (wind confidence 77). The external fuel tanks are to be carried all the way (drop tank treatment +). The aircraft type is the heavy weight version of the B-47E aircraft (aircraft type B47EHW). The flight is to be calculated as written (Tactics Priority Scheme blank).

(2) In the second line the user has indicated that the aircraft (not taking drops tanks or reserve fuel into account) will weigh 100,000 pounds at the end of flight (non fuel - D/Tanks 100,000) and the fuel reserve over base at end of flight will be 5,000 (fuel reserve 005000). Since no inflight refueling is planned the refueling point fuel reserve is not applicable and is left blank. The first point fuel load is left blank because the flight starts with a takeoff and FLIOP is to calculate the takeoff fuel load. Only the name symbol and safety factor are given (takeoff base is Pinecastle and up to 90 per cent of the runway can be used in the takeoff ground roll). By leaving blank the spaces for runway length, pressure elevation, and temperature, the user has indicated that he desires FLIOP to use the data stored in the base table.

(3) In the third and succeeding lines of the Flight Outline Plan form, the user has indicated the following: takeoff from Pinecastle (PNCSTL) using thrust augmentation fluid but no ATO (WOT). The control

time for this flight is 0000 hours 00 minutes at Pinecastle (control time column left blank). From Pinecastle the aircraft is to proceed to $30^{\circ}12'N76^{\circ}42'W$ (3012N07642W in lat. and long. columns) using cruise climb techniques (001 in mode column). The next enroute point is $47^{\circ}15'N53^{\circ}10'W$ and the end point is Lakenheath (LKNHTH). By leaving blank the mode for the last two legs, the FLIOP user has indicated a desire for the aircraft to cruise climb all the way (the last entered mode was 001). Blanks in the wind component and distance fields mean that FLIOP is to compute these quantities. Blanks in the non fuel off load, air refuel and time on orbit fields mean "no bomb drop," "no air refueling," and "no orbiting," respectively. The point symbol column is left blank as it is not used in this type of flight plan. The leaving blank of the degradation factor field means the aircraft has no external drag producers which would produce a degradation in the range capability of the aircraft. The "E" in the control column on the last line indicates that the FLIOP user has described the flight and wishes it to be completed.

(4) The "key problem" of this flight plan is: "With the aircraft type, route, and conditions described here, what is the minimum amount of fuel required on board the aircraft at the time it starts its engines?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Mo.	Wind percentile	Drop tank term.	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXMPLA	04	77	*	B47EHW						

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load	Take off base: Name symbol	Runway length	Sfty. fact.	Press. elev.	Temp.	
100000	005000				PMCSTL		095			

Location: Name symbol	Lat	Long.	Wind components: Tail	Cross	Distance	Non fuel off load	Air refuel: Type	F	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
PMCSTL	N										NOT		o	
	3012 N	07642									001		o	
	4715 N	05310 W											o	
[illegible]	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	
	N												o	

ID	TYPE	PRTY	MO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT	TANKTIME
FXMPLA	8A7EHW	0001	04	77	11163	12000	095	PNCSTL	00400	033	213201	106341		++++++

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
PNCSTL	2826N	08119W					WOT		0000	+00000			224201	102641				A
	3012N	075424	+014	-019	-02	26830	001		0040	+00040	0264	00264	190764	089204				A
......	4210N	06215W	+027	-034	-04	30313	001		0211	+00251	1000	01264	167777	060667			...	A
	4715N	05310W	+019	-014	-01	32055	001		0106	+00357	0497	01756	149621	049041				A
......	5255N	02834W	+018	-002	-00	35601	001		0214	+00611	1000	02756	126855	025295			...	A
......	5235N	00052W	+017	-003	-00	39157	001		0214	+00825	1000	03756	107516	005956			...	A
LKNHTH	5223N	00037E	+009	+006	+06	39349	001		0007	+00832	0052	03808	106550	005000				A

EXAMPLE B

(1) First line

The month is October (10), the wind percentile is 82 per cent (82), the drop tanks are to be carried until no longer needed and then dropped (0), the aircraft is a B-47EHW and no variations in the plan are permitted.

(2) Second Line

The same conditions prescribed in Example A are used here.

(3) Third and succeeding lines

The same route (and enroute conditions) described in Example A apply here. By inserting W2T in the mode column at the takeoff point, the planner has indicated a desire for a "wet" takeoff using either 30 ATO bottles, 18 ATO bottles or no ATO bottles, whichever will permit the maximum amount of fuel on board after takeoff. The control time for the flight is 10 hours and 05 minutes after an unlisted reference time (+01005 in control time column) at takeoff. The "F" in the air refuel type column is used to indicate a desire that the computations start with the aircraft at takeoff and end over the landing base. (See the description of the "key problem" below.)

The "key problem" of this flight is: "With the aircraft type, route, and conditions described here, what is the maximum amount of fuel with which the aircraft can arrive at the end of flight?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Wind Mx. percentile	Drop tech treat	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXCLD	10	02 3	B47EH3						

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pre fuel reserve		First pt fuel load	Take off base: Name symbol	Take off base: Runway length	Take off base: Sfty. fact.	Take off base: Press. elev.	Take off base: Temp.
100000	015000				PNCSTL		090		

Location: Name symbol	Location: Lat.		Location: Long.	Wind components: Tail	Wind components: Cross	Dis-tance	Non fuel off load	Air refuel: Type	Air refuel: F.	Time on orbit	Pt Sym-bol	Mode	Control time	Dogr. fact.	Control column
PNCSTL		N													
	3012	N	07642									WZT	01005	o	
	4715	N	05310									001		o	
LENRTH		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	

```
  ID    TYPE   PRTY NO PERC ROLL  RUNWY SFTY  BASE  ELEV TEMP WT GNR FU GND OPT TANKTIME
EXMPLB B47EMW 0001 10  92  09998 17000  090 PNCSTL 00350 081 223478 114973       +01102

 LOC    LAT    LONG    TAIL CRSS DFT  ALT  MODE  DF  TIME    ETA   DIST TDIST WEIGHT  FUEL  NF OFF FU OFF SYMBOL G
                                           WIT       0000  +01005             212433 110873                      A
PNCSTL 2826N  08119W                                                                                               A
       3012N  07642W  +006 -009 -01 26019  001       0042  +01047  0264 00264 198097 096597                      A
...... 4210N  06215W  +011 -023 -03 31060  001       0216  +01303  1000 01264 168548 066548          ...          A

       4715N  05310W  +024 -021 -04 32640  001       0105  +01408  0492 01756 156718 056718                       A
...... 5255N  02834W  +030 -012 -01 35796  001       0210  +01618  1000 02756 135521 035521          ...          A
...... 5235N  00052W  +016 +011 +01 39053  001       0214  +01832  1000 03756 116646 016646          ...          A
LKNHTH 5223N  00032E  -006 +013 +01 39235  001       0008  +01840  0053 03909 115673 015673                       F
```

EXAMPLE C

(1) This example describes the flight in January (01) of a B-47EHW from Westover over Kindley to a refueling point at 25°00'N70°00'W (the aircraft must have at least 15,000 pounds of fuel on board at the refueling point) at which point the bomber is to take on board the minimum amount of fuel required to complete the mission ("C" type refueling). The tanker is a KC-97 (001 in mode column at that point) and the tanker's fuel off load capability is 40,000 pounds (040000 in $\bar{\bar{F}}$ column at that point).

From the refueling point the bomber is to proceed over Homestead to 29°50'N84°32'W. From this point the aircraft is to proceed to the target (30°20'N86°20'W) at normal rated thrust speed and altitude (011 in mode column) arriving at the target at 9 hours and 20 minutes after a relative zero hour (+00920 in control time column at this point). At the target point, 10,000 pounds of non-fuel weight will be dropped (010000 in non-fuel off load column). After the target, the aircraft is to proceed to 29°05'N89°06'W at normal rated thrust (mode column blank for this leg with 011 indicated for previous leg). Finally the aircraft is to cruise climb to Walker AFB, New Mexico.

(2) The "key problem" for this flight is: "With the aircraft type, route, and conditions described here, what is the minimum amount of fuel required to be transferred at the refueling point to make the flight possible?" The use of a maximum bomber refueling type ("B" in refuel type column) would have resulted in the onloading of the maximum amount of fuel (up to 40,000 pounds) and changed the "key question" to: "What is the minimum feasible takeoff weight?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind percentile	Drop tank symbol	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXMPLE	01	75	+	B-?						

End of flight: Non fuel - D/ tanks	End of flight: Fuel reserve	Refuel dfc fuel reserve		First pt fuel load		Take off base: Name symbol	Runway length	Sfty. fact.	Press. elev.	Temp.
090000	015000	015000				WESTVR		C88		

Name symbol	Location: Lat.	Location: Long.		Wind components: Tail	Wind components: Cross	Distance	Non fuel off load	Air refuel: Type	Air refuel: F.	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
WESTVR		N										WOT		o	
[illegible]		N										001		o	
	2500	N 07000	W					C	040000					o	
[illegible]		N												o	
	2950	N 08432	W											o	
	3020	N 08620	W				010000					011	+ 00920	o	
	2905	N 08906	W											o	
WALKER		N										C01		o	
		N												o	E
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	
		N												o	

ID	TYPE	PRTY	MO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT	TANKTIME
SAMPLE	B47EHW	0001	01	75	10208	11600	038	WESTVR	01100	034	221236	114376		++++++

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
WESTVR	4211N	07231W					HOT		0000	+00335			212236	110676				A
KINDLY	3221N	06440W	+014	+049	+06	27592	001		0141	+00516	0698	00698	184115	082555				A
	2500N	07000W	-031	+039	+05		001		0119	+00635	0572	01270	166997	065437		009101		C
HOMSTD	2528N	08023W	-054	+002	+00	11163	001		0136	+00811	0564	01784	155947	054387				A
	2950N	06432W	-045	-043	-05	32583	001		0054	+00905	0341	02125	145974	044414				A
	3020N	08620W	-079	-025	-03	36368	011		0015	+00920	0098	02223	142390	040870	010000			A
	2905N	08906W	-079	+024	+02	39095	011		0025	+00945	0162	02385	127070	035470				A
WALKER	3317N	10430W	-079	-032	-04	39349	001		0222	+01207	0829	03214	105560	015000				A

EXAMPLE D

(1) This example describes the flight of a KC-97G aircraft from Kindley to 25°00'N69°00'W at 10,000 feet (003 in mode column), orbiting 20 minutes at that point at maximum endurance at 15,000 feet (0020 in time on orbit column and OE3 in mode column at that point), thence to 25°00'N70°00'W at 15,000 feet (003 in mode column) at which point he is to off load 40,000 pounds of fuel (D and 040000 in air refuel column) enroute to 25°45'N75°00'W and on into Homestead.

(2) The "key question" here is: "What is the minimum takeoff weight (and fuel load) required to meet the described conditions?" If a maximum tanker ("E" in refuel type column) had been indicated, the "key question" would have been: "Under the conditions described, what is the maximum amount of fuel this tanker can off load?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind percentile	Drop tank item	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
ENFLD	01	75	-	KC97G						

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel gis fuel reserve		First pt fuel load		Take off base: Name symbol	Take off base: Runway length	Take off base: Stfy. fact.	Take off base: Press. elev.	Take off base: Temp.	
059000	020000					KINDLY		090			

Location: Name symbol	Location: Lat	Location: Long.	Wind components: Tail	Wind components: Cross	Distance	Non fuel off load	Air refuel: Type	Air refuel: P	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
KINDLY		N									W07			
	2500	N 06900									002			
		N							0020		003			
	2500	N 07000					01	CL0000			003			
	2545	N 07500												
ENFLD		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												

ID	TYPE	PRTY	MS	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	AT GND	FU GND	OPT TANKTIME
EXMPLD	KC97G-	0001	01	75	07194	09711	090	KINDLY	00450	069	167617	072164	

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL
KINDLY	3221N	05440W					WOT		0000	+00000			166614	071614			G
	2500N	06900W	-015	+017	+04	10000	002		0234	+00234	0496	00496	156635	060635			A
						15000	053		0021	+00255			153639	058639			A
	2500N	07000W	-017	+001	+00		003		0017	+00312	0054	00550	152599	057599			A
	2545N	07500W	-024	-00[illegible]	-00	15000	003		0196	+00448	0274	00524	105941	011941		040000	D
HOMSTD	2528N	08023W	-027	+00[illegible]	+00	15000	003		0144	+00632	0292	01116	[illegible]	[illegible]			A
																	A

EXAMPLES E AND F

EXAMPLE E

Example E is essentially the same tanker flight as that covered in Example D except that a maximum tanker type refueling is called for (air refuel type E), with the tanker offloading any amount above 30,000 pounds will be acceptable (030000 in $\bar{\bar{F}}$). A "T" card has been placed after the end card. The instructions on this card indicate "after the maximum fuel off load has been computed, store the numbers in the fuel off load column (-0009) of the line carrying the point symbol RF1 (RF1 in point symbol field) in 'storage unit 05'."

EXAMPLE F

This B-47EHW flight plan follows the same general route as Example D; however, two features have been added. A low altitude tactics priority scheme has been indicated (0385 in tactics priority scheme), and three pre-target and four post-target points are listed "over enemy territory" with their appropriate symbols in the point symbol column. The potential refueling point is designated by the insertion of RF1 in the point symbol field. No refueling type or $\bar{\bar{F}}$ need be inserted because the priority scheme will insert this designation if a refueling is required. The value of $\bar{\bar{F}}$ is to be obtained from "storage unit 05" ("T" card preceding the "E" card, -0010 05 at RF1).

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind direction-tde	Drop tank time	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXAMPLE	01	75		-	KC97G-					

End of Mission: Non fuel -D/ tanks	End of Mission: Fuel reserve	Refuel pts fuel reserve		First of fuel load	Take off Data: Name symbol	Take off Data: Runway length	Take off Data: Sfty. fact.	Take off Data: Press. elev.	Take off Data: Temp.	
095000	003000				KINDLY		035			

Name symbol	Location: Lat	Location: Long.	Wind components: Tail	Wind components: Cross	Distance	Non fuel off load	Air refuel: Type	Air refuel: P.	Time on orbit	Pt Symbol	Mode	Control time	Req. fuel	Control column
KINDLY		N									WDT			
	2500	N 06900									002			
		N							0020		0E3			
	2500	N 07000					2	030000		RF1	003			
	2545	N 07500												
HOYSTD		N												
		N												
-0009	05	N								RF1				
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												
		N												

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind percentile	Drop tank term.	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
[illegible]	01	75	0	B47E	0385					

End of flight: Max fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol	Runway length	Sfty. fact.	Press. elev.	Temp.	
[illegible]	015000	015000				WESTVR		088			

Name symbol	Location: Lat	Location: Long.	Wind components: Tail	Wind components: Cross	Dis-tance	Non fuel off load	Air refuel: Type	Air refuel: F.	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
[illegible]		N									WOT		•	
[illegible]		N									001		•	
	2500	N 07100								RF1			•	
[illegible]		N											•	
	2730	N 08250								T-3	010		•	
	2950	N 04932								T-2			•	
	3010	N 08510								T-1			•	
	3020	N 09620				010000				TGT		+00920	•	
	2945	N 09800								T+1			•	
	2905	N 08906								T+2			•	
	3000	N 09203								T+3			•	
	3105	N 09545								EXT			•	
[illegible]		N									001		•	
-C220	05	N								RF1			•	T
		N											•	E
		N											•	
		N											•	
		N											•	
		N											•	
		N											•	
		N											•	

ID	TYPE	PRTY NO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLE	KC97G-	0001 01	75	07948	09711	086	KINDLY	00450	069	175000	079547	

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
KINDLY	3221N	06440W					WOT		0000	+00000			173997	078997				A
	2500N	06900W	-015	+017	+04	10000	002		0233	+00233	0496	00496	162504	067504				A
						15000	0E3		0021	+00254			160321	065321				A
	2500N	07000W	-017	+001	+00		003		0017	+00311	0054	00550	159240	064240		046172	RFI	E
	2545N	07500W	-014	-000	-00	15000	003		0136	+00447	0274	00824	106941	011941				A
KCKSTD	2520N	08023W	-017	+003	+00	15000	003		0144	+00631	0292	01116	103000	008000				A

ID	TYPE	PRTY	NO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLF	B47EMW	0464	01	75	10208	11600	[illegible]	WESTVR	01100	034	221236	109376	+00719

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	RF OFF	FU OFF	SYMBOL	G
WESTVR	4211N	07221W					ROT		0000	+00336			212236	105676				A
KINDLY	3221N	0644[illegible]	+014	+049	+06	27592	001		0141	+00517	0698	00698	184115	077555				A
	25[illegible]N	0700[illegible]	-031	+039	+05		001		0119	+00636	0527	01220	166927	060437		044180	RF1	C
HOMSTD	2528N	[illegible]	-057	+022	+[illegible]	28931	001		0141	+00817	0564	01784	185491	[illegible]				A
	2730N	[illegible]	+[illegible]	+[illegible]	+[illegible]	[illegible]	010		0025	+00842	0178	01962	1740[illegible]	[illegible]			T-3	A
	2959N	[illegible]	+[illegible]	+[illegible]	+[illegible]	[illegible]	010		0024	+00906	0165	02125	167349	042349			T-2	A
	3010N	0261[illegible]W	+[illegible]	+0[illegible]	+[illegible]	[illegible]	010		0005	+00911	0038	02165	165224	040224			T-1	A
	302[illegible]N	0862[illegible]	+[illegible]	+[illegible]	+[illegible]	[illegible]	010		0009	+00920	0061	02227	1620[illegible]	057[illegible]	015000		TGT	A
	2945N	[illegible]	+[illegible]	+[illegible]	+[illegible]	[illegible]	000		0016	+00936	0093	02320	1421[illegible]	052135			T+1	A
	2905N	[illegible]	+000	+[illegible]	+[illegible]	[illegible]	000		0012	+00948	0070	02390	1364[illegible]7	045497			T+2	A
	3000N	09203[illegible]	+[illegible]	+[illegible]	+[illegible]	[illegible]	000		0027	+01015	0163	02553	1298[illegible]	0[illegible]391			T+3	A
	3105N	09545[illegible]	-062	-037	+04	33142	001		0035	+01050	0201	02754	121644	031644			EXT	A
ELLSWR	4408N	10324[illegible]	-034	-064	+05	41337	C01		0212	+01202	0856	03610	105000	015000				A

EXAMPLE G

This flight plan represents the flight of a B-47 from Lockbourne, taking a maximum bomber (B type) on load near Newfoundland by a KC-135 (101 in the mode column at RF1), another "B" type refueling from a KC-97 over north Spain, subsequently cruising down the Mediterranean to Turkey with a subsequent return to Tanejon, Spain. The -0021 type "T" card is used here to illustrate the "break point" technique. The question being asked here is: "How far down the Mediterranean can this aircraft go still returning to Torrejon?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Mo.	Wind percentile	Drop tank frmt	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
[illegible]	07	75	•	B-47E[illegible]						

End of flight: Non fuel -D/tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol	Take off base: Runway length	Take off base: Sftn fact.	Take off base: Press. elev.	Take off base: Temp.	
100000	010000	015000				LOKERN		095			

Location: Name symbol	Location: Lat	Location: Long.		Wind components: Tail	Wind components: Cross	Distance	Non fuel off load	Air refuel: Type	Air refuel: F	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
LOKERN		N										WOT		•	
	4325	N 05110	W					B	090000		RF1	101		•	
	4310	N 00500	W					B	050000		RF2	001		•	
	3500	N 01500	E											•	
	3400	N 02500	E											•	
	3700	N 03500	E											•	
TORRAN		N									LDB			•	
-0021		N									LDB			•	T
		N												•	E
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	

ID	TYPE	PRTY	NO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLG	R47ENW	0001	07	75	10403	11900	295	LCKBRN	01150	086	199883	093023	******

LOC	LAT	LONG.	TAIL	CRSS	OFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
LCKBRN	3942N	08255W					NOT		0000	+00000			190883	089323				A
******	4637N	06157W	+022	-017	-02	30909	101		0218	+00218	1000	01000	157645	056085			•••	A
	4815N	05117W	+027	-006	-00		101		0059	+00317	0443	01448	146631	045071		090000	RF1	B
******	4759N	02605W	+020	+001	+00	26100	001		0214	+00531	1000	02448	197348	095758			•••	A
	431 N	00503W	+014	+007	+01		001		0205	+00736	0928	03376	169120	067560		050000	RF2	B
******	3608N	01442E	+015	+009	+01	27843	001		0227	+01003	1000	04376	181979	080419			•••	A
	3600N	01500E	-004	+008	+00	27909	001		0007	+01005	0016	04392	131461	079901				A
	3470N	02500E	+023	+003	+00	29686	001		0107	+01112	0505	04897	167031	065471				A
	3528N	03344E	+023	-014	-01	31276	001		0100	+01212	0453	05350	155122	053562				A
TORRJN	4028N	00327W	-036	-007	-01	38363	001		0427	+01639	1750	07100	111560	010000			LDP	A

EXAMPLE H

Multiple control time (#### in time on orbit column to indicate the "free orbit point"). Use of degradation factor 06.2 per cent is indicated as desired all the way.

ETA at (RF1) transfer to storage is indicated.

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind percentile	Drop tank trmt.	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXMPLH	01	75	*	B47EHW						

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol	Take off base: Runway length	Take off base: Sfty. fact.	Take off base: Press. elev.	Take off base: Temp.	
100000	010000	015000				PLTTSB		090			

Name symbol	Location: Lat.	Location: Long.	Wind components: Tail	Wind components: Cross	Dis-tance	Non fuel off load	Air refuel: Type	Air refuel: F.	Time on orbit	Pt Sym-bol	Mode	Control time	Degr. fact.	Control column
PLTTSB	N										WOT	00100	•	
	5300 N	05600 W					B	040000		RF1	001		06•2	
	6000 N	04400 W											06•2	
	N								••••				06•2	
LKNHTH	N											00815	06•2	
	N												•	E
-0023	59 N									RF1			•	T
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	
	N												•	

ID	TYPE	PRTY	MO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLH	B47E4W	0001	01	75	04684	11760	090	PLTTSB	01100	027	165827	058967	++++++

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
PLTTSB	4440N	07330W					NOT		0000	+00100			156827	055257				A
	5300N	05600W	+043	-026	-03		001	06.2	0153	+00253	0349	00849	131720	030160		040000	RF1	B
	6000N	04400W	+034	-017	-02	31559	001	06.2	0125	+00418	0576	01425	152393	050323				A
						32513	001	06.2	*0034*	+00452			145772	044212				A
******	5644N	01220W	+022	+025	+03	36366	001	06.2	0213	+00705	1000	02425	122419	020859			***	A
LKNHTH	5223N	00032E	+013	+006	+00	38363	001	06.2	0110	+00815	0522	02947	111560	010000				A

EXAMPLE I

Example I is a flight plan for a KC-97 from Goose Bay to refuel the bomber in Example H. Storage to ETA is indicated so tanker takeoff can be calculated.

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	No.	Wind percentile	Drop tank trmt.	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXMPLI	01	75	-	KC97G-						

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load	Take off base: Name symbol	Take off base: Runway length	Take off base: Sfty. fact.	Take off base: Press. elev.	Take off base: Temp.	
100000	005000				GOOSBY		090			

Location: Name symbol	Location: Lat.		Location: Long.		Wind components: Tail	Wind components: Cross	Dis-tance	Non fuel off load	Air refuel: Type	Air refuel: F	Time on orbit	Pt Sym-bol	Mode	Control time	Degr. fact.	Control column
GOOSBY		N											WOT		•	
	5300	N	05900	W									002		•	
		N									0015		0E2		•	
	5300	N	05600	W					D	040000		RF1	003		•	
	6000	N	04400	W									003		•	
NRSRSS		N													•	
-0024	99	N										RF1			•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	

ID	TYPE	PRTY	MO	PERE	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLI	KC97G-	0001	01	75	05570	11000	090	GOOSBY	01400	008	161053	060600	

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
GOOSBY	5318N	06024W					WOT		0000	+00151			160050	060050				A
	5300N	05900W	+006	+012	+03	10000	002		0018	+00209	0054	00054	157790	057780				A
						10000	0E2		0015	+00224			156947	056947				A
	5300N	05600W	+017	+010	+02		003		0029	+00253	0108	00162	154371	054371		040000	RF1	D
	6000N	04400W	+014	-011	-03	15000	003		0245	+00538	0576	00738	105987	005987				A
NRSRSS	6108N	04522W	-010	-017	-05	15000	003		0026	+00604	0079	00817	105000	005000				A

EXAMPLE J

In this case the flight plan is started "in mid-flight" with the first point fuel load being specified. The "break point" technique is used ("T" card -0021) and a 10,000 pound off load is indicated at an impossibly remote "break point." The wind components to be used on the second leg are inputs by the user.

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Mo.	Wind percentile	Drop tank trmt.	Aircraft type	Tactics priority scheme		D/T option point		D/T option time	
EXMPLJ	10	75	O	B47EHW			DEC			

End of flight: Non fuel -D/ tanks	End of flight: Fuel reserve	Refuel pts fuel reserve		First pt fuel load		Take off base: Name symbol	Runway length	Sfty. fact.	Press. elev.	Temp.	
093000	010000			098273							

Location: Name symbol	Lat.	Long.		Wind components: Tail	Cross	Distance	Non fuel off load	Air refuel: Type	F	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
	4000	N 04000	W									001	00930	•	
	6500	N 02900	W	030	041						DEC	001		•	
	7200	N 13500	E				010000							•	
REFLVK		N						F			LDB			•	
-0021		N									LDB			•	T
		N												•	E
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	
		N												•	

ID	TYPE	PRTY	MC	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	AT GND	FU GND	OPT	TANKTIME
EXVPLJ	B47EHW	0001	10	75									DEC	+01253

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	OF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
	4000N	04000W					001		0000	+00930			202833	094273				A
	6300N	02900W	+030	-041	-05	30896	001		0323	+01253	1547	01547	157964	057404			DEC	A
••••••	8117N	01511W	+009	-014	-01	35994	001		0217	+01510	1000	02547	134291	031291			•••	A
••••••	8200N	01312W	+004	-010	-01	36148	001		0006	+01516	0045	02592	133343	030343	010000		•••	A
KEFLVK	6156N	02235W	-024	+016	+02	41753	001		0242	+01758	1090	03682	103008	010008			LDB	F

EXAMPLE K

This is an illustration of the "deviation time" technique. ("T" card -0020) Note: This technique can only be used in forward motion calculations ("F" in air refuel type column on last point). The questions here are: "Given a B-47 leaving Pinecastle at +00300 enroute to Lakenheath, at what point will he turn if ordered to "deviate" to Keflavik at +009297" "How much fuel will he have aboard upon arrival at Keflavik?"

FLIGHT OUTLINE PLAN

Form 2
1-6-59

ID	Mo	Wind percentile	Drop tank trml	Aircraft type	Tactics priority scheme		D/T option count		D/T option time	
[illegible]	[illegible]	30	•	[illegible]						

End of flight: Non fuel -D/ tanks	Fuel reserve	Refuel pts fuel reserve		First pt fuel load	Take off base: Name symbol	Runway length	Sfty. fact	Press. elev.	Temp	
102560	005000				PNCSTL		090			

Location: Name symbol	Lat.		Long.		Wind components: Tail	Cross	Distance	Non fuel off load	Air refuel: Type	P	Time on orbit	Pt Symbol	Mode	Control time	Degr. fact.	Control column
PNCSTL		N														
	3012	N	07642										ALT	•00300	•	
	4715	N	05310										C01		•	
LENGTH		N													•	
KEFLVK		N													•	
-0020		N										ALT			•	
		N										ALT		•00929	•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	
		N													•	

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

ID	TYPE	PRTY	MO	PERC	ROLL	RUNWY	SFTY	BASE	ELEV	TEMP	WT GND	FU GND	OPT TANKTIME
EXMPLK	B47EMW	C001	10	62	10167	12000	090	PNCSTL	00350	081	225038	114573	******

LOC	LAT	LONG	TAIL	CRSS	DFT	ALT	MODE	DF	TIME	ETA	DIST	TDIST	WEIGHT	FUEL	NF OFF	FU OFF	SYMBOL	G
PNCSTL	2226N	08117W					WIT		0000	+00200			213993	110873				A
	3012N	07642W	+005	-009	-01	25859	001		0042	+00342	0264	00264	199579	094459				A
******	4210N	06219W	+011	-023	-03	29463	001		0216	+00558	1000	01264	168768	069649			***	A
	4719N	05310W	+072	-030	-04	31198	001		0105	+00703	0492	01756	155687	052547				A
******	5256N	02834W	+029	-012	-01	34662	001		0211	+00914	1000	02756	132519	029709			***	A
******	5313N	02534W	+015	+005	+03	35754	001		0015	+00929	0109	02865	130121	027001			***	A
KEFLVK	6358N	02235W	-012	-026	-03	37486	001		0132	+01101	0652	03517	116203	013093			ALT	F

UNCLASSIFIED

AD 227 738

FOR
MICRO CARD
CONTROL ONLY

2 OF 2

Reproduced by

Armed Services Technical Information Agency

ARLINGTON HALL STATION; ARLINGTON 12 VIRGINIA

UNCLASSIFIED